***United States Court of Appeals***

***for the Second Circuit***

# EXHIBITS

B

75-7362

# United States Court of Appeals

**FOR THE SECOND CIRCUIT**

**Docket No. 75-7362**

PERMA RESEARCH & DEVELOPMENT COMPANY,

*Plaintiff-Appellee,*

—v.—

THE SINGER COMPANY,

*Defendant-Appellant.*

ON APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF NEW YORK

UNITED STATES COURT OF APPEALS
FILED
DEC 29 1975
A. DANIEL FUSARO, CLERK
SECOND CIRCUIT

## EXHIBIT BINDER

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POLETTI FREIDIN PRASHKER
FELDMAN & GARTNER
*Attorneys for Plaintiff-Appellee*
777 Third Avenue
New York, New York 10017

WINTHROP, STIMSON, PUTNAM
& ROBERTS
*Attorneys for Defendant-Appellant*
40 Wall Street
New York, New York 10005

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| 8 | Patent #2,881,879 Accelerator Brake Control, dated April 14, 1959 | E-3 |
| 9 | Patent #3,325,226 Braking System and Anti-Skid Means Therefor, dated June 13, 1967 | E-18 |
| 10 | Patent #3,330,113 Power Brakes, dated July 11, 1967 | E-36 |
| 11 | Patent #3,383,482 Switch Devices, dated May 14, 1968 | E-53 |
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| 14 | Letter to Frank Perrino from Keith Heffer, Sales Manager, The Singer Company of Canada, Ltd., dated Jan. 21, 1964 | E-101 |
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| 17 | Letter to Frank Perrino from Robert Kloby, dated Feb. 19, 1964 | E-103 |
| 18 | Singer-Elizabeth Division Manufacturing Services Quality Control Brochure | E-105 |
| 18A | Complete Brochure Described in Plaintiff's Exhibit 18 | E-107 |
| 19 | Motor Vehicle Research Report No. 13, Published at Lee, New Hampshire, 1964 | E-135 |
| 20 | Ads, Brochures, Article Reprints of the Perma Anti-Skid Device | E-[illegible] |
| 21 | Cadillac Engineering -- 1963-1964, Perma Anti-Skid Tests | E-164 |
| 22 | Report of C. R. Fricke of Singer on Meeting Held March 13, 1964 Concerning Perma's Anti-Skid Control | E-165 |
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| 24 | Anti-Skid Device: Test Specifications for Pressure Switch Equipment by J. Wagner, dated May 22, 1964 | E-323 |
| 25A | Memorandum to R. Kloby from R. Patten Re: Perma Research and Research Development Company Market and Forecast, dated May 27, 1964 | E-326 |
| 27 | Agreement Between Perma Research and Development Company and Jandro Equipment Co. of Minneapolis, Minn., dated March 7, 1964 | E-330 |
| 28 | Manufacturer's Agent Agreement Between Thomas H. Coulter of Des Moines, Polk County, Iowa and Perma Research and Development Company, with Price List for Tom Coulter Representative Agreement Attached, dated Sept. 4, 1964 | E-336 |
| 29 | Agreement Between Perma Research and Development Company and Clarelen Importers, Ltd., dated June 10, 1963 | E-340 |
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| 34 | Agreement Between The Singer Company of Canada,Ltd. and O-Matic Auto Products, Ltd., dated Jan. 1, 1965 | E-372 |
| 35 | Contract Between Perma Research and Development Company and The Singer Company, dated June 18, 1964 | E-378 |
| 38A | Group Memoranda Entitled: (a) Meeting Between Perma and Singer Personnel, dated Sept. 2, 1964 (b) Meeting Between Perma, American Optical and Singer Personnel, dated Sept. 3, 1964 (c) Meeting Between Perma, Singer and American Optical Personnel, dated Sept. 8, 1964 With Results of Test (Sept. 8, 1964) | E-402 |
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| 47 | Minutes of Meeting of Sept. 24, 1964--Subject: Perma Anti-Skid Unit | E-420 |

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| 49 | Memorandum to C. W. Broeker from A. Romel--Subject: Status Report "Perma", dated Sept. 28, 1964 | E-425 |
| 53 | Memorandum to J. Fecko from A. Romel Re: "Perma Sensing Units", dated Dec. 4, 1964 | E-431 |
| 54 | Memorandum Re: Discussion Between Perma & Singer Personnel, dated July 17, 1964 | E-432 |
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| 59 | Memorandum to D. P. Kircher from L. E. Hough, dated Dec. 11, 1964 | E-454 |
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| 62 | Letter to S. J. Murphy from P. Phelps, dated Jan. 7, 1965 | E-5[illegible]2 |
| 63 | Letter to P. Phelps from Carl W. Broeker, dated Feb. 17, 1965 | E-515 |
| 64 | Agreement Between Monitor Enterprises, Inc. and The Singer Company, dated Jan. 18, 1965 | E-517 |
| 65A | Letter to Frank Perrino from A. Romel, dated Dec. 23, 1964 | E-531 |
| 77 | Memorandum to E. A. Sprague from A. Romel Re: Original Sketches of Transfer Valve and Attachments | E-536 |
| 79 | Letter to Marshall Breen from E. A. Sprague, dated June 16, 1965 | E-540 |
| 82 | Letter to C. G. Morehouse from R. R. Patten, dated July 7, 1965 | E-541 |
| 88A | Memorandum to A. di Scipio from B. C. Person Re: Suspension of Marketing and Withdrawal of Units from Field - PERMA Anti-Skid Control, and Exhibits, dated Aug. 10, 1965 | E-543 |
| 89 | Memorandum to B. C. Person from David McKearnan, dated Aug. 16, 1965 | E-553 |
| 90A | Memorandum to D. P. Kircher from D. D. Marsden Enclosing Perma Anti-Skid Status Report and Recommendations, dated Aug. 30, 1965 | E-557 |

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| 92 | Letter from B. C. Person to Frank Perrino, dated Sept. 9, 1965 | E-568 |
| 94 (pages 3-5) | Portion of Report Letter to B. C. Person from C. W. Broeker with Report Attached, dated Sept. 1, 1965 | E-570 |
| 98B | Schematic Showing Modifications for "Fail Safe" and Higher Brake Pressures; Schematics Nos. 2 and 3 | E-573 |
| 99 | Memorandum to A. di Scipio from B. C. Person - "Recommended Course of Action for Perma Anti-Skid Control Program", dated Nov. 9, 1965 | E-576 |
| 100 | Memorandum to B. C. Person from Alfred di Scipio Re: Recommended Course of Action for Perma Anti-Skid Program, dated Nov. 11, 1965 | E-585 |
| 102 | Letter from B. C. Person to Frank Perrino, dated Nov. 22, 1965 | E-586 |
| 104 | Letter to R. D. Mainelli from B. C. Person, dated Dec. 23, 1965 | E-587 |
| 105, page 3 (Schedule B) | Singer Report dated June, 1965: Perma Anti-Skid Device Investment and Commitments as of June, 1965 | E-588 |
| 110 | Letter to B. C. Person from C. R. Odermann, dated Nov. 8 , 1965, enclosing Denville Special Report #62 "A Technical Evaluation of the Perma Anti-Skid Control Based on Present Design" by John A. Lundin | E-589 |
| 120 | Memorandum to D. D. Marsden from R. S. Torello, dated Dec. 21, 1964 | E-603 |
| 121 | SAE Booklet "Evolution of Sure-Track Brake System" | E-609 |
| 122 | Portion of Plaintiff's Pre-Trial Memorandum, Perma Research & Development Co. v. The Singer Co. and Additional Reasons Rendering the Perma Anti-Skid Device Unmarketable, dated Oct. 6, 1972 | E-628 |
| 123 | Simulation of Perma Anti-Skid Device (24:1) | E-636 |
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| 129 (first 3 stops) | Computer Simulation of Perma Anti-Skid Device, Gear Ratio 18:1 | E-651 |
| 130 | Anti-Skid Control: General Description of Major Assemblies, dated May 7, 1965 | E-657 |
| 131 | Anti-Skid Control: General Description of Major Assemblies, dated May 7, 1965 | E-673 |
| 132 | Vehicle Equations of Motions by A. DeVilliers | E-689 |
| 133 | Numerical Constants Used In Vehicle Simulation | E-691 |
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| 134 | Equation of Perma Device, A. DeVilliers' Model | E-693 |
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| 136 | SAE Paper Entitled "Tire-Road Friction Measuring System - A Second Generation" by G. Goodenow, T. Kolhoff, F. Smithson | E-699 |
| 140 | Statistical Abstract of the United States: Motor Vehicles 1972 | E-708 |
| 142 | Diagram of Cam Gear | E-713 |
| 143 | Road Surfaces Denoted by 60 MPH Sliding Coefficient of Friction | E-714 |
| 144 | Annual Report, 1965, The Singer Company | E-718 |
| 147 | The Singer Company: Experimental and Test Data Sheet, dated Nov. 30, 1964 | E-745 |
| 150 | Application for Patent #322,716 Entitled "Braking System and Anti-Skid Means Therefor", filed Nov. 12, 1963 | E-746 |
| 154 (at 23) | Ford Sure-Track Manual | E-819 |
| 155 (Chapter 5) | Chrysler Service Manual, 1972 | E-820 |
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| 160 | Plot of A. DeVilliers' Computer Simulation at 60 MPH, .75 mu, 12:1 gear ratio | E-982 |

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| 161 | Plot of A. DeVilliers' Computer Simulation at 40 MPH, .75 mu, 12:1 Gear Ratio | E-985 |
| 163 | 1969 New Model Training: Brake Systems Workbook | E-990 |

II. Defendant's Exhibits Received In Evidence

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| 1 | Soundtrack of Perma Promotional Film (Transcribed Nov. 14, 1973) | E-1017 |
| 8 | Three-part Cardboard Display Entitled "Perma Anti-Skid Control" | E-1027 |
| 10 | History of the Perma Research and Development Company, 1952-1962 | E-1030 |
| 11 | Letter from G. J. Salustro of Ford Motor Company to G. Lee Dienes of Perma Research and Development Company, dated June 15, 1964 | E-1039A |
| 12 | 1964 Ford Test Results | E-1040 |
| 20 | Letter from L. H. Nagler of American Motors Corporation to Roger Levesque, dated June 26, 1964 | E-1042 |
| 25 | Special Report No. 2, Confidential | E-1044 |
| 36 | Two Field Reports: 1) From Roger Levesque and Tom Perrino to F. A. Perrino, R. D. Mainelli and J. Krawczyk. Installation of Steel Drive Gears in Connecticut State Police Cruisers. Westport Barracks and Bethany Barracks. 2) From Tom Perrino to F. Perrino, R. Mainelli, J. Krawczyk and L. Dienes. Connecticut State Police - Westport Barracks, c/o Safety Service Corp. Replacement of Plastic Speedometer Gear with Steel Replacement Gear, dated July, 1964 | E-1046 |
| 44 | Report from Roger Levesque to F. A. Perrino, R. D. Mainelli, J. Krawczyk, L. Dienes and S. Karp, dated Aug. 27, 1964 | E-1050 |
| 53 | Affidavit of Frank A. Perrino, dated Nov. 18, 1969 | E-1051 |
| 102 | Letter from J. Gomes to R. A. Kloby, dated July 23, 1964 | E-1067 |
| 111 | Memorandum from A. Romel to C. W. Broeker re: "Gear Boxes" for Perma Anti-Skid Units, dated Oct. 26, 1964 | E-1068 |
| 114 | Memorandum from A. Romel to C. W. Broeker re: Summary of Gear Box Test Results, dated Nov. 16, 1964 | E-1073 |

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| 115 | Memorandum from A. Romel to C. W. Broeker re: Summary of Gear Box Test Results, dated Nov. 24, 1964 | E-1076 |
| 118 | Memorandum from A. Romel to C. W. Broeker re: Summary of Gear Box Life Test Results, dated Dec. 3, 1964 | E-1080 |
| 191 | Letter from Cecil S. Morris to S. J. Murphy re: Attached Report Outlining Singer's Position Under Manufacturing Licensing Agreement with Perma Research and Development Company, dated Oct. 21, 1964 | E-1083 |
| 195 (pages 1-4) | Letter from S. Karp to Robert Patten of The Singer Company re: Estimated Budget Projection, dated Nov. 30, 1964 | E-1093 |
| 197 | Letter from S. Karp to Ed Wright of Car Controls, Inc. Instructing Him to Withhold Perma Anti-Skid from the Market, dated Dec. 11, 1964 | E-1098 |
| 233 | Memorandum from A. Romel to C. W. Broeker re: Summary of Gear Box Life Test Results, dated Dec. 23, 1964 | E-1099 |
| 234 | Memorandum from A. Romel to C. W. Broeker re: Endurance Testing of Sensing Unit, dated Dec. 28, 1964 | E-1102 |
| 236 | Memorandum from A. Romel to C. W. Broeker re: Summary of Endurance Tests on the Sensing Unit, dated Feb. 1, 1965 | E-1103 |
| 242 | Memorandum from A. Romel to C. W. Broeker re: Summary of Endurance Tests on the Sensing Unit, dated Feb. 10, 1965 | E-1105 |
| 313 | Memorandum from H. Hnojowy to R. A. Kloby re: Testing of the Pressed Metal Filters, dated July 12, 1965 | E-1107 |
| 323 | Report from P. Urban to A. Romel Entitled, "Effect of Low Temperature on .030/.032" Diameter Metering Valve," dated Dec. 1, 1965 | E-1109 |
| 336 | Letter from A. Romel to B. C. Person re: The Ford Motor Company Trip, dated March 15, 1966 | E-1153 |
| 380 | Letter from S. Karp to R. R. Patten re: Need to Replace Units Installed on Consumers', Stockholders' and Dealers' Cars, dated Dec. 28, 1964 | E-1155 |
| 409 | Document Entitled "Perma Research and Development Co." | E-1156 |

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| 417 | Memorandum from R. A. Kloby to C. W. Broeker re: Letter Dated Jan. 7, 1965 from P. Phelps to S. J. Murphy | E-1166 |
| 479 | Organization Announcement from D. P. Kircher, President of Singer, Announcing the Establishment of a New Operating Division to Bring Together Most of the U.S. Units Primarily Concerned with Consumer Products, dated June 25, 1965 | E-1170 |
| 487 | Memorandum from B. C. Person to A. di Scipio re: Attached Study Plan for the Anti-Skid Control Prepared for the Use of the Study Team, dated July 26, 1965 | E-1173 |
| 502 | Letter from R. A. Wolf, Head, Transportation Research Dept. of Cornell Aeronautical Laboratory, Inc., to B. C. Person re: Suggestion for a Three-phase Program of Research, dated Sept. 1, 1965 | E-1178 |
| 529 | Letter from R. A. Kloby to B. C. Person re: Attached Engineering Evaluation of the Latest Modifications Submitted by Perma to Provide a "Fail-Safe" Feature in the Anti-Skid Control Unit, dated Nov. 16, 1965 | E-1180 |
| 529A | "Fail-Safe Analysis of Piston and Check Valve Modification", dated Nov. 10, 1965 | E-1195 |
| 530 | Memorandum from the Perma Anti-Skid Control Task Force to A. di Scipio re: Recommended Course of Action for the Perma Anti-Skid Control Program, dated Nov. 18, 1965 | E-1196 |
| 577 (excluding appendices) | Booklet Entitled "Technical Status Report - Perma Anti-Skid Device", dated July 22, 1965 | E-1202 |
| 595 | Investment and Expenditures for Perma Anti-Skid Device | E-1227 |
| 603 | Letter from R. A. Kloby to B. C. Person re: Perma Program Inventory Attachments, dated Oct. 20, 1965 | E-1228 |
| 618 | Cancelled Singer Check in the Amount of $85,000.00 to the Order of Monitor Enterprises, Inc., dated Sept. 1, 1965 | E-1230 |
| 653 (Cover, p.7 "Advanced Control Concepts" thru p.11 to "Adaptive Steering") | SAE Document #690260, "Technological Development Directing the Path to Fully Automatic Vehicle Control Systems", by S. I. MacDuff, J. G. Rivard, E. J. McGlinn | E-1231 |
| 655 | SAE Document #710248, "The Chrysler 'Sure-Brake' - The First Four-Wheel Anti-Skid System", J. W. Douglas, T. C. Schafer | E-1237 |

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| 656 | Executed Copy of Technical Services Contract Between Perma Research and Development Company and The Singer Company, dated Dec. 21, 1964, With Cover Letter from F. A. Perrino, dated Dec. 21, 1964 | E-1248 |
| 670 | Due to Its Excessive Size, by Stipulation Dated Aug. 7, 1975, DX 670 (Blueprint of Vacuum Container DC 17-342066-900X) is in the Possession of Counsel for Defendant. DX 670 Will be Produced for the Court's Inspection Upon Request. | E-1253 |
| 686 | "Perma Anti-Skid Detail of Start-Up Manufacturing Expenses July 1 - Dec. 31, 1964" | E-1254 |
| 687 | Employee History and Compensation Records (Top Page: Albert E. Romel) | E-1256 |
| 688 (p. 909 thru p. 910 to "Measurement Methods") | Article on Measurement of Tire Brake Force Characteristics as Related to Wheel Slip (Antilock) Control System Design by J. L. Harned, L. E. Johnston and G. Scharpf | E-1270 |
| 689 (p. 298 "Abstract", p. 299 "Braking and Safety" thru p. 306, p. 317 "Automatic Regulation Devices" thru p. 318) | Article on Automatic Brake Proportioning Devices by Guiseppe Puleo | E-1272 |
| 700 (at 1, 123-124) | 1973 Edition of Ford Brochure Entitled "Car Buying Made Easier" | E-1283 |
| 708 (cover, pp. 1, 13, 15, 22, 27, 31, 34, 35, 40, 44) | Modified Plaintiff's Exhibit 129 | E-1287 |

III. Defendant's Exhibits Offered In Evidence At Trial And Rejected

| | | |
|---|---|---|
| 13 (id) | Engineering Appraisal of "Perma" Anti-Skid Device, dated April 9, 1964 | E-1298 |
| 335 (id) | Memorandum from B. C. Person to S. Boriss, C. W. Broeker and R. H. Elman re: Discussions of Messrs. Romel and Person with Kelsey-Hayes, with Attachments, dated Feb. 15, 1966 | E-1302 |
| 337 (id) | Engineering Reports from The Ford Motor Company to A. E. Samson of Ford re: The Effectiveness of the Anti-Skid Control Unit as Evaluated by Ford | E-1311 |

| Defendant's Exhibit No. | Description of Document | Exhibit Binder Page |
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| 510 (id) | Memorandum from J. A. Lundin to J. W. Momberg of Singer re: Meeting at Denville Research Laboratory on Sept. 30, 1965 | E-1326 |
| 559 (id) | Memorandum from A Romel to B. C. Person re: Trip Report to Ford Motor Company, dated Feb. 17, 1966 | E-1331 |
| 560 (id) | Letter from B. C. Person to C. F. Bruder re: Information Reviewed with D. P. Kircher of Singer, dated Feb. 25, 1966 | E-1336 |
| 658 (id) | Letter from S. Linderman to P. DeRensis re: Plaintiff Counsel's Request for Perma Device - First Unit Delivered, dated May 16, 1973 | E-1339 |
| 659 (id) | Letter from S. Linderman to P. DeRensis re: Plaintiff Counsel's Request for Perma Device - Second Unit Delivered, dated May 22, 1973 | E-1340 |
| 684 (id) | Letter from H. J. Policinski, Patent Attorney for Kelsey-Hayes Co., to J. K. Lagemann re: Every's Testimony, dated June 6, 1974 | E-1341 |

IV. Court's Exhibits

| Exhibit No. | | |
|---|---|---|
| 1 | Letter of P. R. Grand to J. K. Lagemann, dated Nov. 30, 1973 | E-1343 |
| 5, p. 6 (p. 1 of Ex. A to Ct.'s Exhibit 5) | Portion of Partially Executed Stipulation of Facts | E-1345 |
| 6 | Fully Executed Stipulation of Facts, dated June 24, 1974 | E-1347 |

PLAINTIFF'S EXHIBIT 156 (CHAPTER 5)



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# THEORY OF OPERATION

(NOTE: For information pertaining specifically to the Eldorado brake system, refer to the later portion of this section.)

The braking system consists of power-assisted, hydraulically-operated front and rear service brakes and a foot-operated, vacuum-released parking brake that applies the brake shoes at the rear wheels through mechanical linkage.

Single piston sliding caliper front disc brakes and rear drum brakes are installed on all cars.

## Single Piston Sliding Caliper Front Disc Brakes (Fig. 5-1)

The major components of the single piston sliding caliper front disc brake mechanism are the hub and disc assembly, the caliper assembly, the shoe and lining assemblies and the splash shield. The hydraulic system also utilizes a combination valve.

### a. Hub and Disc Assembly

The cast iron hub and disc assembly is fully ventilated with 40 cooling fins cast integrally between the machined braking surfaces. When the wheel is in motion, the rotation of the disc fins increases the air circulation for more efficient cooling of the unit. This disc is protected from cross-car splash by a shield on the inboard side. The disc is grooved on both sides to decrease brake noise.

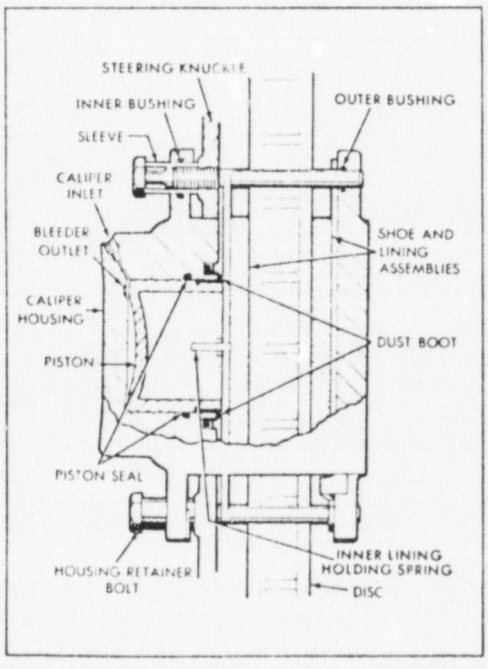



Fig. 5-1 Caliper Cut-Away View

### b. Caliper Assembly

The caliper provides a means of applying the shoe and lining assemblies to the disc. It is hydraulically connected to the system by a tube and flexible hose leading from the brake combination valve to each caliper inlet port. It is mounted to the integral steering knuckle by two housing retainer bolts, two sleeves and four rubber bushings. An inner caliper bushing is installed between each sleeve and groove in the housing, and an outer caliper bushing is installed between each bolt and groove in the housing. Inner and outer shoes and lining assemblies are positioned on the caliper so they straddle the disc.

The one-piece caliper housing is an iron casting that is bored for a single 2-15/16 inch piston and counterbored for a dust boot. A canted groove machined in the cylinder bore accepts a square cut seal that provides a hydraulic seal between the piston and cylinder wall.

The piston is grooved to accept the molded rubber dust boot that provides protection from contamination of the piston and cylinder wall. The boot inner diameter seats on a groove in the poston and the outer diameter is secured to the caliper housing counterbore by a metal ring retainer that is molded in the boot.

When the brake pedal is depressed, hydraulic pressure is exerted within the housing bore equally in all directions. Hydraulic pressure acts on two surfaces causing them to move.

The first is the piston: the second is in the opposite direction against the bottom of the caliper housing bore. Since the area of the piston and bottom of the caliper bore are equal, equal forces are developed.

Hydraulic force in the bore is exerted against the piston and is transmitted to the inner brake shoe and lining assembly and the inner surface of the disc.

The disc is laterally stationary in relation to the steering knuckle. At the same time, an equal hydraulic force presses against the bottom of the bore of the caliper housing. This tends to pull the caliper assembly inboard, sliding on the two pins. The outer lining, which rests on the caliper housing, then applies a force on the outer surface of the disc and together the two linings brake the car.

### c. Brake Combination Valve (Fig. 5-2)

The combination valve is located on the frame side rail extension at the left side of the car. It is connected to the master cylinder by two lines. Two rear lines lead to the caliper assemblies and the front line leading to the rear wheel cylinders. The combination valve incorporates three functions as follows:

1. The metering valve (hold-off section) incorporates lines leading to the caliper assemblies. the metering section of the valve limits pressure to the front disc brakes until a predetermined front input pressure is reached. There is no restriction at inlet pressures below 3

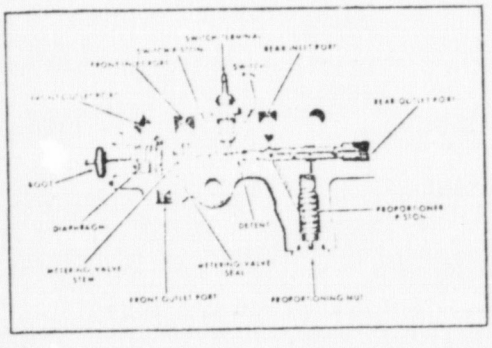



Fig. 5-2 Brake Combination Valve

psi. The purpose of the hold-off valve is to limit pressure to the front disc brakes until the rear drum brakes are activated (rear line pressure must overcome the rear brake shoe return spring tension before the rear brakes actuate).

2. The pressure differential section monitors the front and rear brake systems to measure any difference in pressure from the master cylinder. If a sufficient pressure differential exists between the systems an electrical ground is made energizing the BRAKES tell tale light on the right side of the instrument cluster if the ignition switch is on. The valve and switch are so designed that the switch will latch in the "warning" position once a failure has occurred. The only way the light can be turned off is to repair the failure and apply a pedal force as required to develop up to 450 psi line pressure. This light is also energized during engine cranking for bulb and circuit checking purposes.

3. The proportioning section of the valve proportions outlet pressure to the rear brakes after a pre-determined rear input pressure has been reached. This is done to prevent rear wheel lock-up on a vehicle with light rear wheel loads. The valve is designed to have a "by-pass" feature which assures full system pressure to the rear brakes in the event of a front brake system failure.

(NOTE: The brake combination valve on Limousine and Commercial series does not include the proportioning valve section.)

## Rear Drum Brakes

The rear drum brake system consists of brake shoes (two per wheel) with riveted composition linings acting on cast iron-steel brake drums. The linings are forced against the drums by hydraulic pressure for normal braking and by a foot lever, through mechanical linkage to the brake shoes, for the parking brake.

The wheel cylinder pistons are made of lubricant-impregnated sintered iron to resist corrosion and sticking. A metal expander is used in each piston cup to reduce the possibility of air entering the system during the application and release of the service brake.

The brake linings are positioned in relation to the brake drums by a stationary non-adjustable anchor on each brake assembly and self-adjusting shoe mechanism. This mechanism and the precision-located anchor insure correct lining-to-drum clearances at all times.

The automatic adjusters can engage when the brakes are applied while the car is moving rearward with light pedal application, or after an uphill stop. Adjustment actually occurs only when there is excessive clearance between the lining and the drum.

The star wheel adjuster assemblies incorporate spring steel thrust washers between the adjusting screw and the adjuster end cap. These washers provide a spring-cushioned contact between the primary and secondary brake shoe, thereby absorbing vibrations that could cause squeak when the brakes are applied.

The brake linings are riveted to the shoes. The primary linings are grooved at the center to permit dissipation of heat from the surface of the brake drum, resulting in better brake performance and longer lining life.

Finned, cast iron-steel brake drums are used on the rear wheels to provide maximum cooling.

The parking brake pedal assembly is mounted on the cowl to the left of the service brake pedal. The parking brake will release automatically when the transmission selector lever is moved into any drive position with the engine running. It will not release automatically, however, with the engine running and the selector lever in Neutral or Park, or in any position with the engine off. A manual release lever, located on the inboard side of the parking brake assembly, may be used if the automatic release is inoperative or if manual release is desired at any time.

The parking brake automatic release mechanism is operated by a vacuum diaphragm assembly. When the transmission selector lever is moved into any drive position with the engine running, a vacuum valve in the neutral switch opens, evacuating air from the diaphragm assembly, which in turn disengages the locking mechanism, permitting the parking brake pedal to return to its released position by spring action.

## Tandem Diaphragm Power Brake Unit

The power brake unit used on all cars consists of a tandem disphragm vacuum power section and a dual hydraulic master cylinder.

The master cylinder is designed so that the front and rear service brakes have separate hydraulic systems. The front section of the master cylinder provides fluid for the front brakes, while the rear section provides fluid for the rear brakes. Should a leak occur in the front hydraulic system, the rear brake system will still function. Likewise, if the rear hydraulic system should develop a leak, then the front system would still function. Increased brake pedal travel and an instrument panel brake light warns the driver that such a condition may have occurred.

The hydraulic unit is completely sealed from the atmosphere by rubber seals in the master cylinder reservoir. Atmospheric pressure acts on one side of the diaphragm type seal and reservoir fluid pressure on the other side. This arrangement permits the seal to follow the level of the brake fluid and prevents moisture absorption or dust contamination.

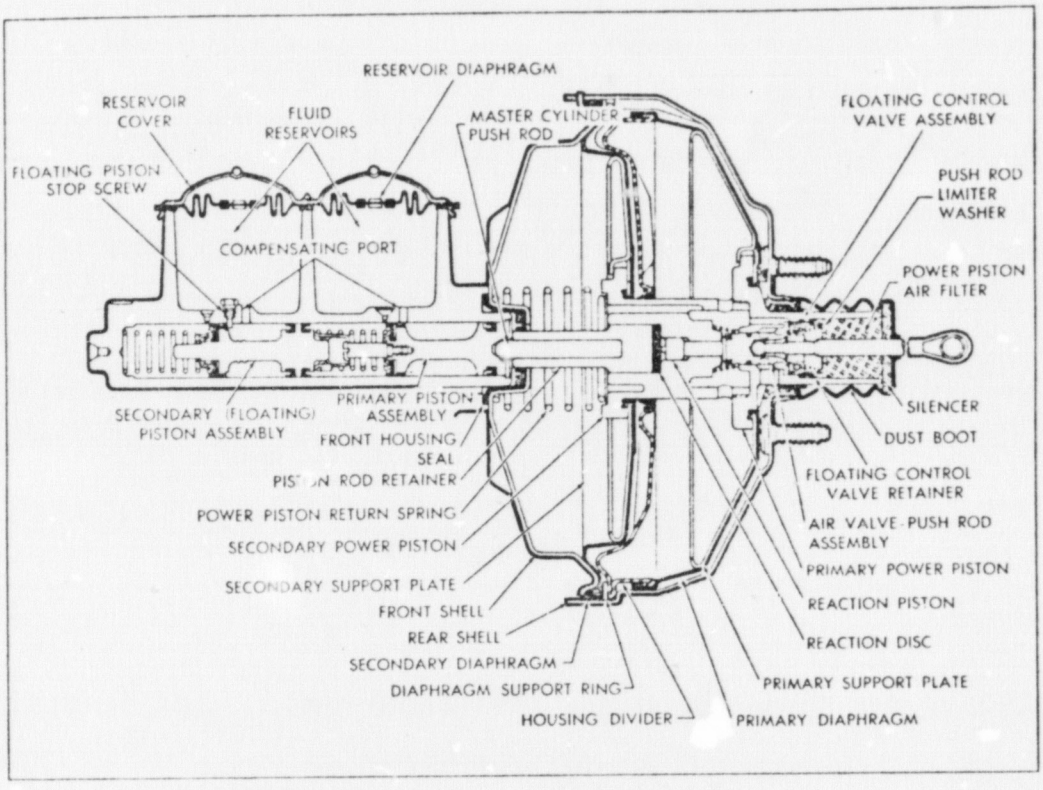



Fig. 5-3 Tandem Diaphragm Power Unit

The tandem diaphragm vacuum power unit has a vacuum power chamber that consists of a front and rear shell, a housing divider, front and rear diaphragm and plate assemblies, a hydraulic push rod, and a diaphragm return spring, Fig. 5-3.

The unit operates so that the two diaphragm and plate assemblies utilize the differential pressure created by engine intake manifold vacuum and atmospheric pressure to assist the hydraulic push rod.

There are several differences between the tandem unit used on Eldorado series as compared to that used on other models. Therefore, these two units should not be interchanged.

The Eldorado unit utilizes a shorter push rod and specific calibration.

## Brake Stoplight Switch

The brake stoplight switch is mounted on a flange on the brake pedal support bracket below the instrument panel. When the brake pedal is depressed, the spring loaded switch plunger follows the brake pedal arm downward until the switch is in the "on" position. When the brakes are released, the arm returns the switch plunger to the "off" position.

## Brake Fluid

It is recommended that Part Number 546 4831 Super Heavy Duty Brake Fluid or equivalent fluids meeting SAE J-1703 specifications be used in Cadillac brake systems.

Brake fluid should always be stored in closed containers, as it will absorb moisture from the atmosphere. Moisture contamination of brake fluid causes the boiling point of the fluid to be lowered.

# DIAGNOSIS

## 1. Testing Brake System

### a. Vacuum Power Section

1. Attach one end of spare windshield washer pump inlet hose to the port nearest the shut-off valve of Leak Testing Tool, J-23108, Fig. 5-4.

2. Disconnect power brake hose to vacuum pipe from carburetor and attach the other end of the windshield washer pump inlet hose to this fitting. A small amount of silicone lubricant will facilitate installation.

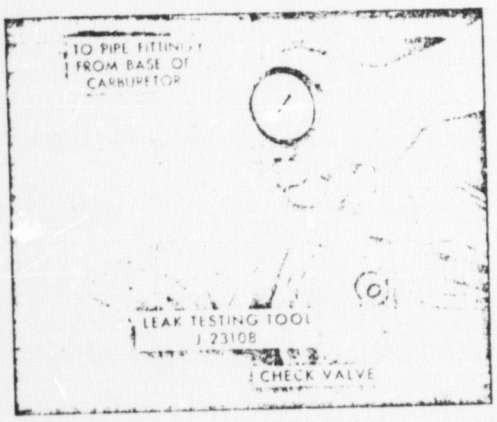



Fig. 5-4 Vacuum Leakage Test

3. Connect the power brake hose to other port of the tester and secure with hose clamp, Fig. 5-4.

4. Run engine at idle for approximately 1/2 minute.

5. Turn off shut-off valve on tee.

6. Note vacuum gage reading.

7. Apply brakes with estimated 20-30 pounds force (the effort required for a moderate stop). While holding pedal force as constant as possible, note vacuum gage reading immediately after applying brake and one-half minute later.

(NOTE: If pedal pressure is relaxed, vacuum reading will be incorrect.)

a. Immediate reading should not be more than six inches of mercury less than initial reading taken after closing shutoff valve. Any release of the brake pedal will increase the reading. Subsequent drop in vacuum reading while holding brakes applied should not exceed two inches of mercury per 1/2 minute. If vacuum leak exceeds specification, power unit must be serviced.

### b. Master Cylinder Section

(NOTE: These tests will not determine all master cylinder malfunctions. Use the diagnosis chart to help isolate the problem if it is not resolved by these tests.)

1. Check for a cracked master cylinder casting or brake fluid around master cylinder.

Leaks are indicated only if there is at least a drop of fluid. A damp condition is not abnormal.

2. Rapidly depress brake pedal. A geyser should be seen at front reservoir as the brake pedal is rapidly depressed.

a. If system fails this test, check for a binding pedal linkage and incorrect push rod adjustment. If both of these are satisfactory, disassemble the master cylinder and check for swollen or elongated primary piston seal(s). Also see Note 3.

### c. Brake Leaks

1. With engine running at idle and transmission in Neutral, depress brake pedal and hold foot pressure on pedal. If pedal gradually falls away under foot pressure, hydraulic system is leaking.

(NOTE: Hydraulic system may be leaking internally as well as externally. See part b, Steps 1 and 2. Also system may appear to pass this test but still have slight leakage.)

### d. Excessive Pedal Travel

1. On cars equipped with Tilt and Telescope steering column, place wheel in third position from top.

2. Hook end of tape over top edge of brake pedal pad, at approximately the center of the pad.

3. Unreel tape to rim of steering wheel, Fig. 5-5.

4. Place thumbnail at edge of wheel and take a reading of the extended length.

5. While holding tape, and with engine idling, press pedal with estimated 20-30 pounds force (the effort required for a moderate stop), and note reading on tape measure. The difference between the two readings is the amount of pedal travel.

Pedal travel should not exceed 2-1/16 inch.

6. If pedal travel is greater than specification, first drive the car backward and forward to see if the brake pedal height will return to normal. In rare cases, excessive pedal travel develops if the car is not driven in reverse because the self-adjusting mechanism will actuate only in reverse when the brakes are applied.

Most low pedal problems are caused by air in lines, necessitating bleeding of the system. It may be necessary to bleed the system several times at each fitting. See Note 6.

Be sure to tap the calipers with a plastic headed hammer in the area of the piston to dislodge air bubbles while bleeding. If pedal travel exceeds specification, there may still be some air in the system.

Other less frequent causes of excessive pedal travel are rear brake shoe adjusters not functioning, shoes require relining, front or rear hydraulic system has lost its fluid, and tapered linings.

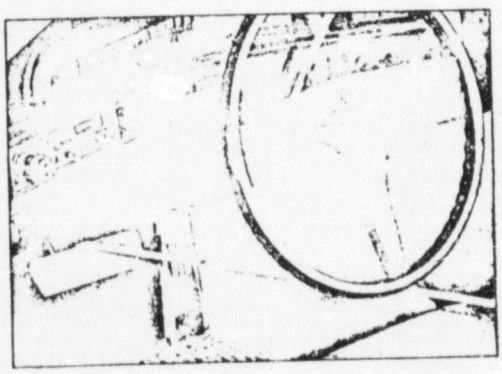


Fig. 5-5 Checking Brake Pedal Height

### e. Road Testing Brakes

Brakes should be tested on dry, clean, smooth and reasonably level roadway which is not crowned. Road test brakes by making brake applications with both light and heavy pedal forces at various speeds to determine if car stops evenly and effectively.

Also drive car to see if it leads to one side or the other without brake application. If it does, check tire pressure, front end alignment and front suspension attachments for looseness. See diagnosis chart for other causes.

## 2. Testing Brake Tell-Tale Light Operation

1. Make sure wire is connected to brake combination valve.

2. Start engine, while ignition switch is in start position, brake tell-tale light should glow and go off when ignition switch returns to ignition position.

3. If system performs as described in step 2, and pedal height is satisfactory (part d of Note 1), the system is all right.

4. If light fails to glow in start position, perform electrical tests outlined in Section 12, Note 27d.

5. If light does not go out with ignition switch in ignition position, disconnect wire from assembly. If light still does not go out, proceed as follows:

a. If car is equipped with Track Master, see Page 5-68.

b. If car is not equipped with Track Master, see Section 12, Note 27e.

If light goes out, this indicates that the terminal is shorted or there is a leak in the brake system. Check pedal height (part d of Note 1). If brake light glows and pedal height is low, check for all conditions listed in diagnosis chart on Page 5-7. If it is determined the terminal is shorted, replace the assembly.

(NOTE: The design of the brake combination valve is such that once a brake leak is sensed by the unit, a ground is made within the switch that will not be broken until the leak is corrected.)

## 3. Substandard or Contaminated Brake Fluid

Improper brake fluid, mineral oil, or water in the fluid may cause the brake fluid to boil or the rubber components in the hydraulic system to deteriorate.

When checking the fluid reservoir level, the level in the front reservoir may be as low as one inch from the top if the front linings are worn. This is not abnormal.

To check for deterioration of rubber parts, perform step 2 of Note 1b. If primary piston cups are swollen, then rubber parts have deteriorated. This deterioration may also be evidenced by swollen wheel cylinder piston cups on the drum brake wheels.

If deterioration of rubber is evident, disassemble all hydraulic parts and wash with alcohol. Dry these parts with compressed air before assembly to keep alcohol out of system. Replace all rubber parts in system including hoses. Also when working on the brake mechanisms, check for fluid on linings. If fluid is found, replace linings.

If master cylinder piston seals are all right, check for a leakage or excessive heat conditions. If condition is not found and still in doubt, drain fluid, flush with brake fluid, refill and bleed system.

## 4. Brake Hose Assembly

Each brake hose assembly should be inspected for obvious damage. An assembly should be replaced if a fitting has separated from the hose or if the hose is ruptured, damaged, worn, or blistered.

In the event of damage, the position of the assembly should be observed to determine if the installation was made properly. Check front brake hose by turning the wheel fully in both directions to determine if interference was the cause. Any interference could be the result of a wrong part or improper installation.

If the hose assembly is wet, the area should be dried. The brake system should be actuated and the assembly observed for leakage or presence of fluid. If fluid appears at the connection between the end fitting and the wheel cylinder or frame connection, the assembly should be removed and the hose fitting and the connection inspected for dirt or other foreign material. After cleaning by wiping or use of air hose, the part may be re-installed and the above check repeated. If fluid reappears, replace the part.

If fluid appears on the hose itself or at the junction of the hose and end fitting, the assembly should be replaced.

## 5. Parking Brake Preliminary Checks

It is not always necessary to replace the parking brake assembly or vacuum diaphragm assembly in cases of an inoperative parking brake automatic release. The following checks should be performed as part of your diagnosis to determine the cause and correction of parking brake trouble and to eliminate unnecessary replacement of parking brake components.

1. Check vacuum cylinder piston travel by running engine and moving transmission selector lever from Drive to Neutral. The manual release lever should move up and down as vacuum is applied and released. If no movement is observed, check vacuum system per steps 2 and 3. If movement is slow, (more than one or two seconds to complete the full stroke) diaphragm is leaking or hoses are partially pinched or kinked. Vacuum diaphragm may be replaced as outlined in Note 21.

2. Check for damaged or kinked vacuum hoses and for loose hose connections at parking brake vacuum cylinder, vacuum release valve at neutral switch, and at engine manifold connection.

3. Check adjustment of neutral switch and operation of vacuum release valve. Correct as necessary and recheck parking brake operation.

4. Check brake release with vacuum applied. If vacuum cylinder piston completes full stroke but does not release brake, a malfunction of the pedal assembly is indicated. Replace complete parking brake assembly as described in Note 20.

5. Check operation of parking brake with engine off. Parking brake should remain engaged regardless of transmission selector lever position. If not, replace parking brake assembly.

## BRAKE DIAGNOSIS CHART

NOTE: Operation of Tell-Tale Brake Light may be checked as outlined in Note 28.

| CAUSE / Symptom | Excessive Brake Pedal Travel | Brake Pedal Travel Gradually Increases | Excessive Brake Pedal Effort | Excessive Braking Action | Brakes Slow to Respond | Brakes Slow to Release | Brakes Drag | Uneven Braking Action (Side to Side) | Uneven Braking Action (Front to Rear) | Scraping Noise from Brakes | Brakes Squeak During Application | Brakes Squeak During Stop | Brakes Chatter (Roughness) | Brakes Groan at End of Stop | Brakes Tell-Tale Glows |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Leaking Brake Line or Connection | X | XX | X | | | | | | X | | | | | | XX |
| Leaking Wheel Cylinder or Piston Seal | X | XX | X | X | | | | X | | | | | | | X |
| Leaking Master Cylinder | X | XX | X | | | | | | X | | | | | | XX |
| Air in Brake System | XX | | X | | | | | | | | | | | | X |
| Contaminated or Improper Brake Fluid | X | | | | X | X | X | | | | | | | | |
| Leaking Vacuum System | | | XX | | X | | | | | | | | | | |
| Restricted Air Passage in Power Head | | X | X | | XX | X | | | | | | | | | |
| Damaged Power Head | | | X | X | X | X | XX | | | | | | | | |
| Worn Out Brake Lining | | | X | X | | | | X | X | X | X | X | | X | |
| Uneven Brake Lining Wear - Replace | X | | | X | | | | X | X | X | X | XX | | X | X |
| Glazed Brake Lining - Sand | | | XX | | X | | | X | X | | X | X | | | |
| Incorrect Lining Material - Replace | | | X | X | | | | X | X | | | X | | X | |
| Contaminated Brake Lining - Replace | | | | XX | | | | XX | XX | X | X | X | | X | |
| Linings Damaged by Abusive Use - Replace | | | X | XX | | | | X | X | X | X | X | | X | |
| Excessive Brake Lining Dust - Remove with Air | | | X | XX | | | | XX | XX | | X | XX | | X | |
| Heat Spotted or Scored Brake Drums or Discs | | | | X | | | | X | X | | X | X | XX | X | |
| Out-of-Round or Vibrating Brake Drums | | | | | | | | | | | | X | XX | | |
| Out-of-Parallel Brake Discs | X | | | | | | | | | | | | XX | | |
| Excessive Disc Run-Out | X | | | | | | | | | | | | X | | |
| Faulty Automatic Adjusters | X | | | | | | X | X | X | | | | | | X |
| Incorrect Wheel Cylinder Sizes | | | X | X | | | | X | X | | | | | | |
| Weak or Incorrect Brake Shoe Retention Springs | | | | X | | X | XX | X | X | XX | X | XX | | | |
| Brake Assembly Attachments - Missing or Loose | X | | | | | | X | X | X | X | | X | X | X | |
| Insufficient Brake Shoe Guide Lubricant | | | | | | | X | X | X | XX | XX | | | | |
| Restricted Brake Fluid Passage or Sticking Wheel Cylinder Piston | | X | X | | X | X | X | X | X | | | | | | X |
| Improperly adjusted Stoplight Switch or Cruise Control Vacuum Dump | | | | | | | X | | | | | | | | |
| Faulty Metering Valve | X | | X | X | X | X | X | | X | | | | | | X |
| Faulty Proportioning Valve | | | X | X | X | X | X | | X | | | | | | |
| Brake Pedal Linkage Interference or Binding | | | X | | X | XX | XX | | | | | | | | |
| Improperly Adjusted Parking Brake | | | | | | | X | | | | | | | | |
| Improperly Adjusted Master Cylinder Push Rod | X | | | | | X | XX | | | | | | | | X |
| Incorrect Front End Alignment | | | | | | | | XX | | | | | | | |
| Incorrect Tire Pressure | | | | | | | | X | X | | | | | | |
| Incorrect Wheel Bearing Adjustment | X | | | | | | | | | X | | | X | | |
| Loose Front Suspension Attachments | | | | | | | X | X | | XX | | | X | X | |
| Out-of-Balance Wheel Assemblies | | | | | | | | | | | | | XX | | |
| Incorrect Body Mount Torque | | | | | | | | | | | | | X | | |
| Need to Slightly Increase or Decrease Pedal Effort | | | | | | | | | | | | | | XX | |
| Operator Riding Brake Pedal | | | X | | | | X | | X | | | | | X | |
| Sticking Caliper or Wheel Cylinder Pistons | | | | | | | XX | | | | | | | | |

XX - Indicates more probable cause(s)
X - Indicates other causes

# SERVICE INFORMATION

(NOTE: For service information pertaining to the Eldorado, refer to the latter portion of this section.)

# BLEEDING AND ADJUSTMENTS

The following caution applies to one or more steps in the assembly procedure of components in this portion of the manual as indicated at appropriate locations by the terminology *"See CAUTION on Page 5-8 prior to Note 6."*

*CAUTION: This fastener is an important attaching part in that it could affect the performance of vital components and systems, and/or could result in major repair expense. It must be replaced with one of the same part number or with an equivalent part if replacement becomes necessary. Do not use a replacement part of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of this part.*

## 6. Bleeding Brakes

Bleeding brakes may be made considerably easier through use of one of the pressure brake bleeder tools available. This equipment consists of a tank partially filled with brake fluid and rubber hose that connects to the hydraulic cylinder reservoir Brake Bleeder Adapter, J-22489-1. Air pressure is applied to the tank to force fluid into the brake system.

Pressure bleeding equipment must be of the diaphragm type. That is, kit must have a rubber diaphragm between the air supply and the brake fluid to prevent air, moisture, oil and other contaminates from entering the hydraulic system.

The Brake Bleeder Adapter, J-22489-1, seals the brake system from the atmosphere during the bleeding operation and enables the brakes to be bled with only one hook-up.

After bleeding brakes, check pedal travel as described in Note 1, part d. Rebleed or adjust brakes as necessary.

*CAUTION: Always use heavy duty brake fluid, part number 546 48-1 or its equivalent to SAE J-1703 specifications.*

Do not spill brake fluid on car finish or damage will result.

### a. Pressure Bleeder Method

1. Remove Master cylinder reservoir cover and seal assembly and fill both reservoirs with fluid.

2. Install Bleeder Adapter, J-22489-1 and cables J-22489-12, on master cylinder and connect bleeder hose to Bleeder Adapter Cover.

3. Install brake combination Valve Bleeder Retainer J-23770 so knob is held closed.

4. Build up pressure in bleeder, 30 Psi minimum if car is not equipped with Track Master proceed to step 6.

5. Attach drain hose at bleeder fitting on modulator on Track Master cars. Back off fitting three quarter turn and bleed brake fluid into a partially filled bottle of clean brake fluid until bubbles stop, then close fitting.

6. Raise car being careful not to damage pressure bleeder equipment.

7. Bleed right rear brake by attaching drain hose to bleeder fitting at wheel.

8. Back off fitting three-quarter turn and bleed brake fluid into a partially filled bottle of clean brake fluid until bubbles stop, then close fitting.

9. Repeat steps 7 and 8 on left rear wheel.

10. Attach drain hose to bleeder fitting on right front caliper.

11. Back off fitting three-quarter turn and bleed brake fluid into a partially filled bottle of clean brake fluid until bubbles stop, then close fitting. During the bleeding operation, tap the caliper lightly and repeatedly with a plastic-headed hammer.

(NOTE: Tapping the caliper is essential on disc brakes, as air bubbles tend to cling to the wall of the caliper.)

12. Repeat operation for left caliper.

13. After bleeding brakes, check pedal travel as described in Note 1, part d. Rebleed brakes if necessary.

(NOTE: As indicated in procedure, brakes are bled in the following order: modulator (Track Master cars) right rear, left rear, right front, left front.)

14. Lower car.

15. Remove Combination Valve Bleeder Retainer, J-23770.

16. Remove pressure bleeding equipment and check reservoir level. Level should be 1/8 inch to 3/8 inch from top.

17. Install master cylinder cover and seal assembly.

18. Before driving car, be sure a firm pedal is obtained.

### b. Alternate Method

If a pressure bleeder is not available the following two man procedure may be used.

1. Fill both master cylinder reservoirs with brake fluid.

(NOTE: Keep reservoirs at least partially filled at all times during bleeding operation. More pedal pumping is required during this bleeding procedure than on cars with drum brakes at all wheels. The fluid level in the master cylinder reservoirs should therefore be frequently checked.)

2. Back off both master cylinder outlet pipe nuts one turn and completely depress brake pedal, catching fluid displaced from outlets in a cloth or can. Retighten

pipe nuts before releasing pressure on brake pedal. Repeat operation four times. Discard this fluid. Refill reservoirs.

(NOTE: If car is not equipped with Track Master, proceed to step 4.)

3. Attach drain hose at bleeder fitting on modulator on Track Master cars, apply pressure to brake pedal, back off fitting three-quarter turn, and depress brake pedal. Close fitting before releasing pressure on brake pedal. Repeat pedal applications until bubbles stop.

4. Raise car.

5. Bleed right rear brake by attaching drain hose to bleeder fitting at wheel.

6. Apply pressure to brake pedal, back off fitting three-quarter turn, and depress brake pedal. Close bleeder fitting before releasing pressure on brake pedal. Repeat pedal applications until bubbles stop.

7. Repeat steps 4 and 5 on left rear wheel.

8. Attach drain hose to bleeder fitting on right front caliper.

9. Apply pressure to brake pedal, back off fitting three-quarter turn, and depress brake pedal. Close bleeder fitting before releasing pressure on brake pedal. Repeat applications until bubbles stop. During the bleeding operation, tap the caliper lightly and repeatedly with a plastic headed hammer.

(NOTE: Tapping the caliper is essential on disc brakes, as air bubbles tend to cling to the wall of the calipers.)

10. Repeat operation for left caliper.

11. After bleeding brakes, check pedal travel as described in Note 1, Part d. Rebleed brakes if necessary.

(NOTE: As indicated in procedure, brakes are bled in the following order: Modulator (Track Master cars), right rear, left rear, right front, left front. Do not rebleed rear brakes unless necessary. Any air left in system will generally be in front brake system, in which case bleed right front and then left front brakes.)

12. Lower car.

13. Check reservoir level. Level should be 1/8 inch to 3/8 inches from top.

14. Install master cylinder cover and seal assembly.

15. Before driving car, be sure a firm pedal is obtained.

## 7. Rear Drum Brake Shoe Adjustment

Although the hydraulic service brakes are self-adjusting, a preliminary star wheel adjustment is necessary after the rear brake shoes have been relined or replaced, or when the length of the star wheel adjuster has been changed during some other service operation. Final adjustment is made automatically by adjusters that function when the car is moving backward. No mechanical adjustment is required when replacing front disc brake shoe and lining assemblies.

1. Raise car and remove rear wheels and drums if not already removed.

2. Check to make certain that parking brake cable and linkage, including levers on rear secondary shoes, are free.

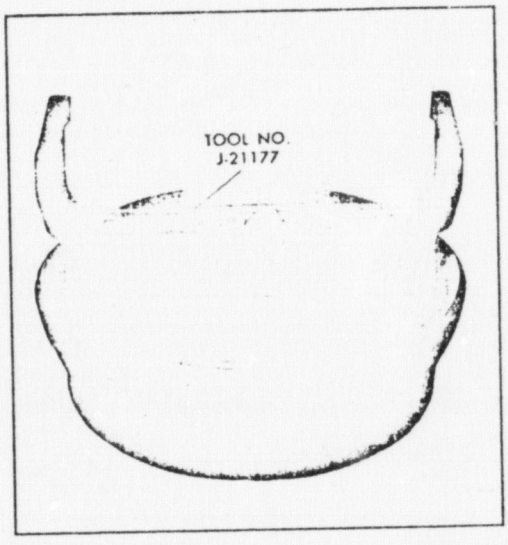



Fig. 5-6 Inside Drum Measurement

3. Measure brake drum I.D. using inside caliper portion of tool J-21177, Fig. 5-6.

4. Adjust brake shoes to dimension obtained on outside caliper portion of tool J-21177, Fig. 5-7.

5. Check brake fluid level in both master cylinder reservoirs. Fluid level should be approximately 1/8 to 3/8 inches below top of reservoir. Add fluid if necessary.

6. Adjust parking brake as described in Note 8.

7. Install drums and wheels. Lower car.

8. Drive car alternately forward and backward, applying brakes moderately in each direction until pedal travel does not exceed specifications listed in Note 1, part d.

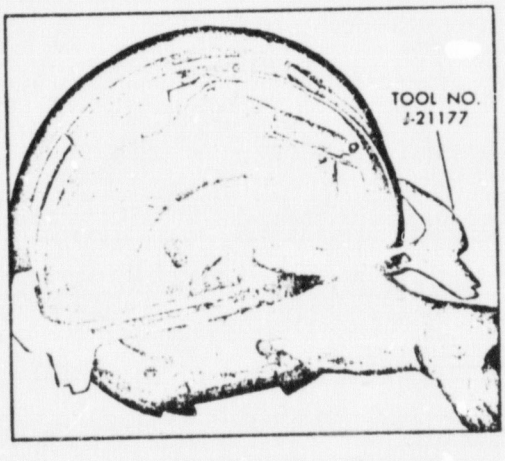



Fig. 5-7 Adjusting Brake Shoes

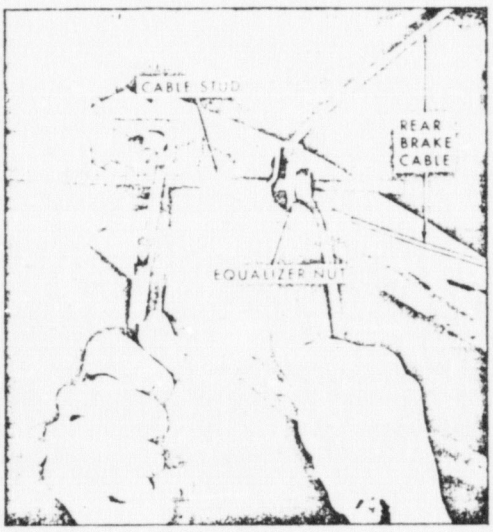



Fig. 5-8 Parking Brake Adjustment

## 8. Parking Brake Adjustment

(NOTE: Make sure that rear drum brakes are properly adjusted before adjusting parking brake.)

1. Lubricate parking brake linkage at equalizer and cable stud, and check for free movement of all cables.
2. Depress parking brake pedal approximately 1.0 inch from fully released position, measuring with a ruler.
3. Raise rear wheels off floor.
4. Hold brake cable stud from turning, and tighten equalizer nut, Fig. 5-8, until light drag is felt on either wheel (going forward). After each turn of equalizer nut, check to see if either wheel begins to drag.
5. Release parking brake. No brake shoe drag should be felt at either rear wheel. Operate several times to check adjustment.

(NOTE: After adjustment is performed, parking brake pedal should travel 1¾ inches to 3 inches on 6B, C, D, F and Z and 2½ inches to 4 inches on 6L with approximately 125 pounds force on pedal.)

6. Lower rear wheels.

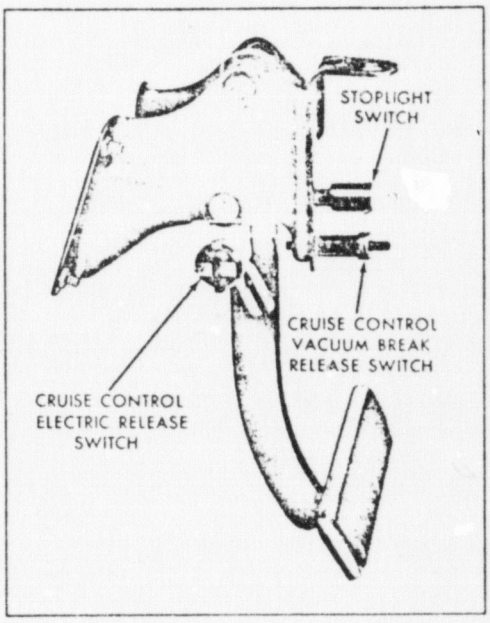



Fig. 5-9 Stoplight Switch Location

## 9. Stoplight Switch Adjustment

The brake stoplight switch and Cruise Control switch are adjusted in an identical manner. Push the switch well into the retaining clip. Pulling the brake pedal fully up to its stop will automatically adjust the switch, Fig. 5-9.

Rotate switch 1/2 turn counterclockwise to be sure that stoplight switch or Cruise Control switch does not hold brake pedal on after adjustment. There should be free play between brake pedal and bracket when pedal is pulled toward released direction from unapplied position.

# FRONT DISC BRAKES

## 10. Disc Brake Relining (All)

(NOTE: Check lining on brakes any time wheels are removed. (Tire rotation, etc.). Inboard lining may be checked by looking through inspection hole in caliper. When thickness of any lining is about the same as the thickness of the metal shoe, all shoe and lining assemblies should be replaced.)

1. Remove two thirds of the total fluid capacity in the front master cylinder reservoir. Discard fluid.

(NOTE: Removing the fluid prevents reservoir overflow when the piston is pushed back in its bore to remove the caliper.)

2. Raise car and remove front wheels.
3. Position 7 inch "C" clamp on the caliper so that solid side rests against back of caliper assembly. The screw end rests against back of outboard shoe, Fig. 5-10.
4. Tighten "C" clamp until caliper moves out far enough to push piston to bottom of piston bore. This will release the pressure on shoe and lining assemblies.
5. Remove "C" clamp.
6. Remove two bolts using a 3/8 drive and Socket Assembly, that hold caliper to steering knuckle, Fig. 5-11.

(NOTE: It is not necessary to remove brake hose when relining disc brakes.)

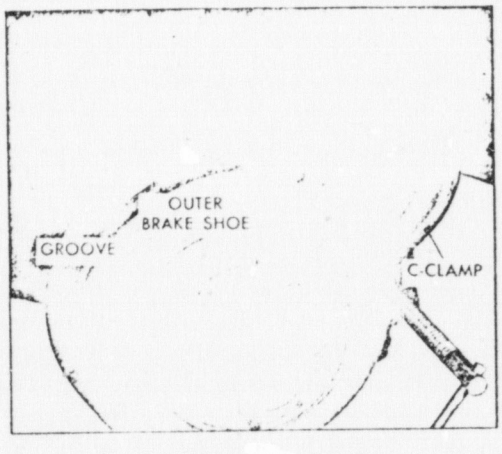



Fig. 5-10 Pushing Piston into Bore

7. If working on Eldorado, it will be necessary to remove cotter pin, loosen upper ball joint nut and slip brake hose collar out of its clip. The slack gained will permit removal of caliper without pulling hose.

8. Remove two screws securing caliper to steering knuckle and slide caliper off disc and support with a hook-shaped wire fastened to upper control arm.

*CAUTION: Do not allow caliper to hang from brake hose.*

9. Remove inboard shoe and spring from piston.

10. Remove outboard shoe from caliper.

11. Push out two sleeves from inboard ears of the caliper.

12. Remove four rubber bushings, two on inboard ears and two on outboard ears.

13. Examine piston area for fluid leaks by looking for excessive moisture around boot area. Check dust boot for cuts, cracks or other damage which would affect its ability to seal piston bore. If leaks are present or boot shows damage, caliper should be overhauled as described in Note 13. If no defects are found, wipe clean the inside of the caliper including four ears where bushings are installed. Wipe the outside surface of the dust boot clear of all dirt so that when piston is pressed to bottom of bore, boot will fold back without coming out of groove in piston.

*CAUTION: Do not use air for cleaning caliper because of the possibility of unseating dust boot.*

14. Examine both sides of disc for scoring or rough finish. Refer to Note 15 to determine condition of disc. In normal use, a slight ridge of rust may form on the edge of the disc. This ridge may be removed with sandpaper.

15. Make sure the piston is bottomed in the piston bore. Make sure the dust boot has folded back correctly as the piston moved back.

16. Wipe out grooves in caliper ears and install new bushings.

17. Lubricate new sleeves on outer surface with silicone lubricant. Install the sleeves and position the sleeve so that end toward the shoe and lining assembly is flush with the machined surface or the ear.

18. Secure clip-on spring to inner shoe inside cut-out section of piston. Install inboard shoe and lining assembly.

19. Place the outboard shoe and lining in the caliper so that the lining faces toward the disc. The two ears at the ends of the shoe fit over the ears on the caliper. The flange on the bottom of the shoe fits into the cut-out section of the caliper.

20. Position caliper on disc and line up holes in caliper ears with holes in steering knuckle. Make sure the brake hose is not twisted as its natural curvature is essential to maintain proper hose-to-suspension clearance through full movement of suspension and steering parts.

21. Wipe all dirt and corrosion from the caliper mounting bolts. Do not use abrasives, as they will remove protective plating. Lubricate smaller ends of bolts with silicone lubricant.

22. Start either bolt into the inboard ear of the caliper and into the steering knuckle. At this point it is necessary to be sure that the bolt passes under the retaining ear on the inboard shoe to maintain the shoe in position in the caliper, Fig. 5-11.

23. Pass the bolt on through the outboard ear on the caliper and brake shoe until the threads on the bolt can be started into the steering knuckle.

24. Repeat steps 22 and 23 in placing remaining bolt into caliper assembly.

25. Tighten caliper mounting bolts, using a 3/8 drive and a Socket Assembly, to 30 foot-pounds. (For steps 25, 29, 31 *see CAUTION page 5-8 prior to Note 6.)*

26. Pump brake pedal to seat lining against disc.

27. Clinch upper ears of outboard shoe by positioning 12" pliers with one jaw on top of upper ear and one jaw in notch on bottom of shoe, opposite upper ear, see Fig. 5-12.

(NOTE: After clinching, there should be no radial clearance between the shoe ears and caliper housing.)

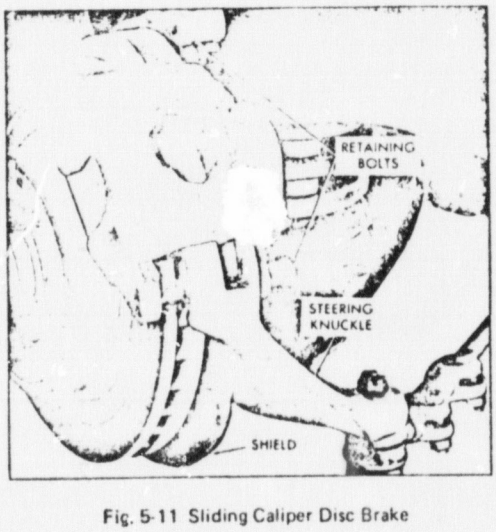



Fig. 5-11 Sliding Caliper Disc Brake

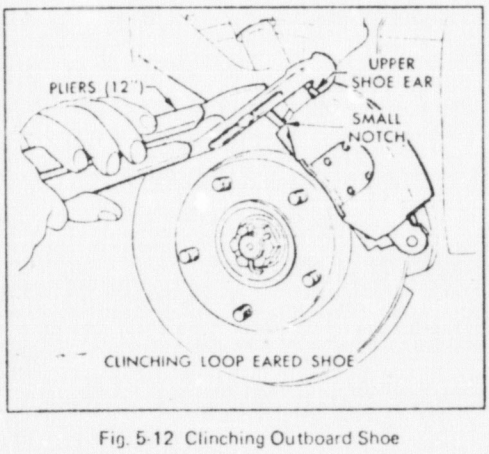



Fig. 5-12 Clinching Outboard Shoe

28. If radial clearance exists, repeat clinching procedure.

29. If working on an Eldorado, center brake hose collar in clip and tighten upper ball joint nut to 60 foot-pounds. Install cotter pin.

30. Repeat steps 3 through 28 on other brake assembly. Always reline both front brakes.

31. Install wheels, tighten wheel mounting nuts to 130 foot-pounds, and lower car.

32. Before moving the vehicle, pump the brake pedal two or three times to insure firm pedal.

33. Allow car weight to be supported on front wheels and inspect front brake hoses for twisted condition. If necessary, correct as described in Note 24a and b.

34. Check the master cylinder reservoirs and fill to 1/8 to 3/8 inch from top.

35. Any time the front brakes are relined, the rear drum brakes should be checked.

36. Break in new linings as described in Note 11.

## 11. Break-In of New Linings (All)

New or replacement brake linings, if subjected to normal usage at speeds under 50 MPH need no special break-in. However, the first few brake applications may be somewhat erratic, and it may be necessary to stabilize the brakes before delivering the car to the owner. If brake action is erratic, one acceptable way to seat the brakes is to make five or ten moderate brake stops at speeds of 30 to 40 MPH, at approximately one-half mile intervals.

## 12. Disc Brake Caliper Assembly (All)

### a. Removal

1. Remove two thirds of the total fluid capacity in the front master cylinder reservoir. Discard fluid.

(NOTE: Removing fluid prevents reservoir overflow when the piston is pushed back in its bore to remove the caliper.)

2. Raise car and remove wheels.

3. Position a "C" Clamp on the caliper so that solid side rests against back of caliper assembly. The screw end rests against back of outboard shoe, Fig. 5-10.

4. Tighten "C" clamp until caliper moves out far enough to push piston to bottom of piston bore. This will release the pressure on shoe and lining assemblies.

5. Remove "C" clamp.

6. Disconnect steel brake line from hose and cap fittings to prevent dirt from entering brake line or hose.

7. Remove U-shaped retainer from hose fitting and withdraw hose from frame support bracket. On Eldorado remove upper ball joint cotter pin and nut. Slide hose clip off ball joint stud. On right side of Eldorado remove clip located at frame side bar.

8. Remove two bolts using a 3/8 drive and Hex Setscrew Socket that hold caliper to steering knuckle.

9. Slide caliper off disc.

10. Remove inboard shoe from caliper.

11. Outboard shoe may have disengaged itself from caliper as caliper was removed from disc. If it did not disengage itself, remove outboard shoe.

12. Place caliper on clean workbench and remove hose and copper washer from caliper inlet fitting. Discard washer.

13. Overhaul caliper as described in Note 13.

### b. Inspection of Disc

1. With caliper assembly off disc, inspect disc as described in Note 15.

### c. Installation

1. Connect brake hose to inlet hole on caliper using a new copper washer. Tighten to 30 foot-pounds maximum torque.

2. Make sure piston is bottomed in piston bore. Make sure the dust boot has folded back correctly as piston moved back.

3. Secure clip-on spring to inner shoe inside cut-out section of piston. Install inboard shoe and lining assembly.

4. Place outboard shoe and lining in caliper so that lining faces toward disc. The two ears at ends of shoe fit over ears of caliper. Flange on bottom of shoe fits into cut-out section of caliper.

5. Position caliper on disc and line up holes in caliper ears with holes in steering knuckle.

6. Lubricate smaller ends of caliper bolts with silicone lubricant.

7. Start either bolt into inboard ear of caliper and outboard ear of shoe into steering knuckle. At this point it is necessary to be sure that bolt passes under retaining ear on inboard shoe to maintain shoe in position in caliper, Fig. 5-11.

8. Pass bolt on through outboard ear on caliper until threads on bolt can be started into steering knuckle.

9. Repeat steps 7 and 8 in placing remaining bolt into caliper assembly.

10. Tighten caliper mounting bolts to 30 foot-pounds.

11. Pump brake pedal to seat lining against disc.

12. Clinch upper ears of outboard shoe by positioning 12" pliers with one jaw on top of upper ear and one jaw in notch on bottom of shoe, opposite upper ear. Fig. 5-12.

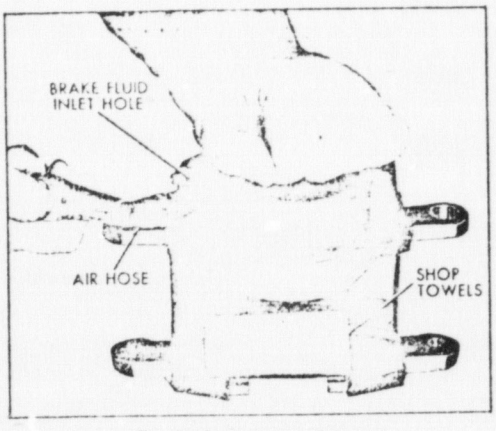



Fig. 5-13 Removing Piston

(NOTE: After clinching, there should be no radial clearance between the shoe ears and caliper housing.)

13. If radial clearance exists, repeat clinching procedure.

14. Install wheel and tighten mounting nuts to 130 foot-pounds torque. (For steps 10 and 14 *see CAUTION on page 5-8 prior to Note 6.)*

15. With suspension in normal position (Front wheel straight and vehicle weight on front wheels) pass female end of hose through frame support bracket, allowing hose to seek its own position. Insert hex of hose fitting into the 12-point hole in support bracket in position that will result in least twist in hose.

(NOTE: Do not twist hose any more than necessary during this operation as its natural curvature is essential to maintain proper hose-to-suspension clearance through full movement of suspension and steering parts.)

16. Install U-shaped retainer to secure hose in frame support bracket. On Eldorado install hose and clip on upper ball joint stud. Install nut. Torque to 60 foot-pounds and insert cotter pin.

17. Inspect by turning steering from stop-to-stop while observing hose position. Be sure that hose does not touch other parts at any time during steering travel. If contact does occur, remove hose retainer and rotate female hose end in support bracket one or two points in appropriate direction, replace retainer, and re-inspect.

18. Place steel tube connector nut in hose fitting and tighten to 20 foot-pounds maximum torque.

19. Bleed all brakes as outlined in Note 6.

20. Before moving car, pump brake pedal two or three times to insure a firm pedal.

## 13. Disc Brake Caliper Disassembly, Cleaning, Inspection and Assembly (All)

### a. Dissassembly

1. Remove caliper assembly as described in Note 12a.

2. Clean the caliper exterior with denatured alcohol.

3. Push out two sleeves from inboard ears of the caliper.

4. Remove four rubber bushings, two on inboard ears and two on outboard ears.

5. Place a pad of clean shop towels on caliper bridge, Fig. 5-13.

(NOTE: The towels will prevent damaging the piston when it is pushed out by air pressure.)

6. Use service air hose to apply moderate air pressure to brake fluid inlet hole to force piston out of caliper. Keep fingers clear of piston.

*CAUTION: Use clean air only. Air supplies that are lubed or oiled contain mineral oil that will damage rubber parts.*

7. Using a screwdriver, pry boot out of housing, being careful not to scratch bore, Fig. 5-14. Discard boot.

8. Using a plastic toothpick, remove piston seal from groove in bore and discard seal.

*CAUTION: Do not any metallic device to remove the seal, as it y scratch or damage the bore or groove.*

9. Remove bleeder fitting from caliper assembly.

### b. Cleaning and Inspection

1. Inspect the caliper brake hose for worn spots, cracks or other signs of deterioration. Replace if necessary.

2. Inspect the piston for scoring, pitting, nicks, corrosion and worn or damaged chrome plating. If any of these faults appear, it will be necessary to replace the piston.

3. The bore should be inspected for the same defects as the piston with the exception of chrome plate. Stains or corrosion can be polished with fine crocus cloth. Wash caliper bore with clean denatured alcohol. If the defects cannot be cleaned up in this manner, it will be necessary to replace the caliper.

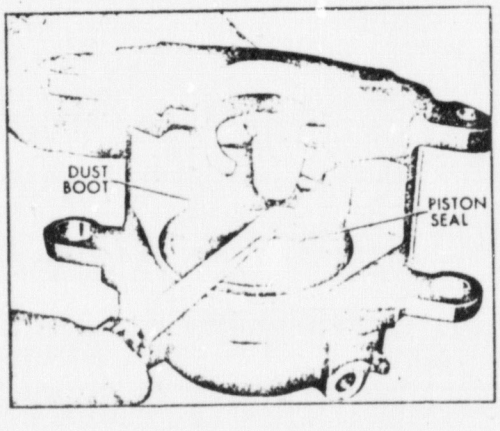



Fig. 5-14 Removing Dust Boot

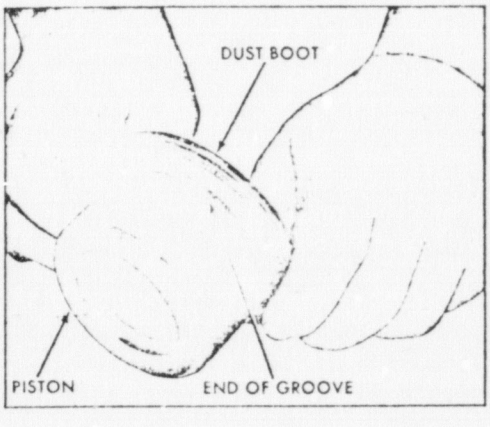



Fig. 5-15 Assembling Dust Boot on Piston

4. All passageways should be blown out with clean air.

5. Clean the caliper mounting bolts and caliper ear grooves of all dirt and corrosion. Do not use abrasives on bolts, as they will remove protective plating.

### c. Assembly

1. Install bleeder fitting in caliper.

2. Lubricate piston bore and new piston seal with brake fluid.

3. Position the new seal in the groove in the piston bore.

4. Assemble new dust boot on piston, so that inner diameter of boot is secured in groove and boot fold faces away from closed end of piston, Fig. 5-15.

(NOTE: Do not use previously removed boot.)

5. Lubricate sealing surface of piston with brake fluid. Position piston in bore and press it down to bottom of bore. Make certain dust boot does not disengage from groove in piston.

6. With dust boot evenly positioned in caliper counterbore, position Boot Installer, J-22904, on boot and tap with a plastic hammer to seat boot, Fig. 5-16.

7. Lubricate four new bushings with silicone lubricant and install bushings in caliper ears.

8. Lubricate new sleeves with silicone lubricant and install in inboard caliper ear. Position the sleeve so that end toward the shoe and lining assembly is flush with the machined surface of the ear.

9. Install caliper assembly as described in Note 12c.

## 14. Hub and Disc Assembly

### a. Removal

1. Remove wheel disc and loosen wheel mounting nuts on side from which steering knuckle is to be removed.

2. Raise front end of car and place jack stands under front frame side rails.

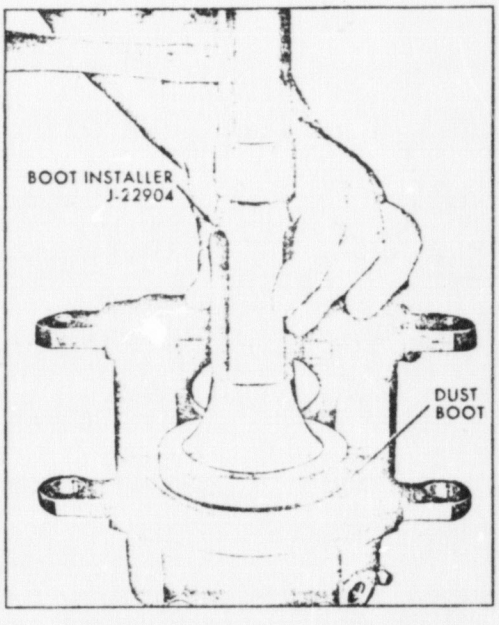



Fig. 5-16 Installing Dust Boot in Caliper

3. Remove wheel mounting nuts and remove wheel and tire.

4. Remove two bolts securing brake caliper to steering knuckle. Slide caliper off disc and use a piece of wire to attach caliper to upper control arm.

*CAUTION: Never allow caliper to hang from brake hose.*

5. Remove dust cap, cotter pin, spindle nut, and washer.

6. Remove outer cone and bearing assembly.

7. Remove hub and disc assembly from steering knuckle spindle.

### b. Installation

1. Install hub and disc assembly on spindle.

2. Install washer and spindle nut, tightening nut with fingers.

3. Install caliper following Steps 3 through 10 of Note 12c. Pump brake pedal two or three times to insure a firm pedal.

4. Adjust wheel bearings as in Section 3 Note 17a.

5. Install wheel and tire and install wheel mounting nuts finger tight.

6. Raise car, remove jack and jack stands, and lower car.

7. Tighten wheel mounting nuts to 130 foot-pounds.

8. Install wheel disc.

## 15. Servicing Discs

When performing any service on front disc brakes, inspect the disc ventilation passages for obstructions,

such as salt or mud build-up. Any build-up must be removed because it decreases brake cooling, which might lead to increased lining wear rate and brake shudder.

When new linings are installed, the disc should be lightly sanded using a circular non-directional motion. A slight ridge of rust may form on the edge of the disc, during normal use. This ridge should be removed during the sanding operation.

Scoring of the disc, due to advanced wear of linings, does not always necessitate replacement of the disc. Discs with scoring of the surface up to approximately .020 inch in depth are not detrimental to brake operation and may be used with new linings.

Once a wear pattern has been established, front disc brake cars are not as susceptible to problems occurring because of scored discs as front drum brake cars are due to scored drums.

In normal servicing of worn lining or on caliper removal, lateral runout of the disc need not be checked, except when brake shudder is evident.

If brake shudder develops after long periods of use, it may be caused by light surface deposits (such as lining oxides) on the braking surface of the disc. These deposits, which appear as a dark blotch about the size of half-dollars, may be removed by sanding.

Brake shudder on low mileage cars may be caused by excessive disc lateral runout or out-of-parallelism.

Before checking runout and parallelism, check disc thickness. If total disc thickness is less than 1.215 inch on all except the Eldorado or 1.190 inch on the Eldorado, the disc must be replaced. Some discs may already be at minimum thickness, so the di. must be checked before attempting a refinishing operat. n.

When checking runout of the "C" car, first tighten front wheel bearing to take up end play. If "C" car lateral runout is in excess of .005 inch, or parallelism is in excess of .0007 inch, the disc should be refinished or replaced.

On the Eldorado, lateral runout of the hub and disc assembly must not exceed .008 inch or parallelism .0005 inch. If these specifications are exceeded, the disc should be refinished or replaced. When checking runout on this car, the wheel nuts must be installed with the flat portion of the hex against the disc to retain the disc against the hub.

The hub and disc assembly (except Eldorado), is a cast integral unit and is not interchangeable with the Eldorado hub and disc. The Eldorado hub and disc are replaceable separately. On all cars it is not necessary to replace both front hub and disc assemblies when only one is defective. Replace only defective hub and discs.

Since extremely accurate control of the finishing operation is necessary for proper performance, refinishing of the rubbing surface is not recommended unless precision equipment is available and surfaces can be held within specifications listed.

# REAR DRUM BRAKES

## 16. Rear Drum Brake Shoe Assemblies

When brake relining is necessary, it is recommended that the complete brake lining and shoe assemblies be replaced with new assemblies. New lining and shoe assemblies are precision-ground to fit the drum diameter, minimizing the possibility of imperfect braking action due to warped brake shoes or partial contact between linings and drum.

Those Service Departments that have adequate brake shoe relining equipment may obtain linings, drilled and cut to size, from their servicing Parts Distribution Center. Brake lining grinding equipment should incorporate brake shoe holders that locate the shoes accurately in relation to the anchor end, as brake anchors are not adjustable and require accurately ground linings.

## 17. Relining Rear Drum Brakes (All Except 693) (Fig. 5-17)

1. Release parking brake, raise car, and remove rear wheels.
2. Remove rear brake drum assemblies.
3. Loosen parking brake cable locknut on equalizer.
4. Remove primary brake shoe retracting spring, using Brake Spring Remover and Installer, J-8049.
5. Disconnect link at anchor and remove link, secondary brake shoe retracting spring, and anchor plate.
6. Remove primary brake shoe hold-down cup, spring and pin, and secondary brake shoe hold-down pin, cup, spring, and sleeve.
7. Remove pawl return spring, actuating lever, and pawl.
8. Disengage brake shoes from wheel cylinder connecting links and parking brake strut rod. Remove strut rod and spring.

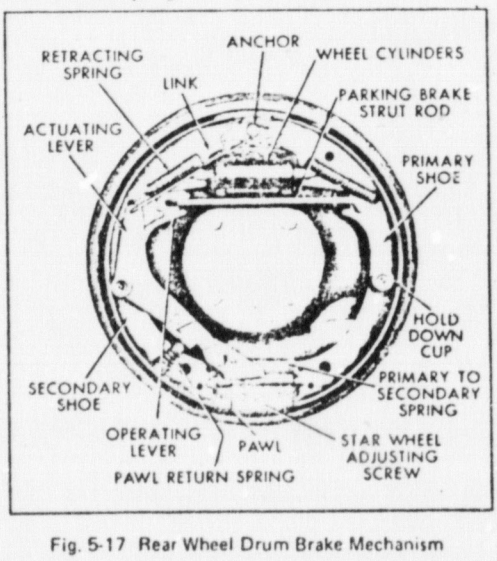



Fig. 5-17 Rear Wheel Drum Brake Mechanism

9. Disconnect parking brake cable from operating lever on secondary shoe and remove complete shoe and lining assembly from brake backing plate.

10. Remove star wheel adjuster and primary to secondary connecting spring from shoe assembly.

11. Remove clip from pin on secondary brake shoe and remove operating lever and pin assembly.

12. Clean brake backing plate and all brake parts.

*CAUTION: Make certain that hands are c[illegible] when handling brake parts and avoid handling friction surfaces of drums and linings.*

13. Tighten nuts that hold backing plate to rear axle housing to 40 foot-pounds maximum torque.

*(See CAUTION page 5-8 prior to Note 6.)*

14. Install operating lever and pin assembly on replacement secondary brake shoe and secure with clip.

15. Lubricate threads and socket of star wheel adjuster and points of contact between brake and other brake parts with a heat resistant lubricant, part number 545 0032 or its equivalent. Use sparingly, especially on brake shoe pads.

16. Thread star wheel adjusting screw completely into pivot nut to permit installation of brake drum over replacement brake shoes.

17. Install star wheel adjuster and primary-to-secondary connecting spring on brake shoes. Make certain that star wheel rotates in proper direction.

(NOTE: Maroon springs are used on both left and right hand rear brake shoe assemblies. These springs are interchangeable.)

Star wheel adjusters with three wide grooves on O.D. of pivot nut (left hand threads) Fig. 5-18 are installed on right side of car and those with three narrow grooves on O.D. of pivot nut (right hand threads) must be installed on left side.

18. Position shoe assembly on brake backing plate and connect parking brake cable to operating lever.

19. Install parking brake strut rod and spring on brake shoe assembly.

(NOTE: Light blue spring is used on left side and white spring on right side. These springs are not interchangeable. Spring tab must be positioned outside of brake shoe web on both rear brakes.)

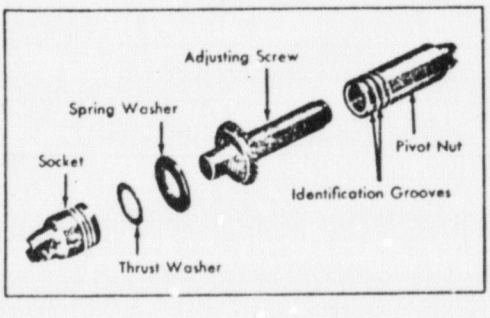



Fig. 5-18 Star Wheel Adjuster Disassembled

20. Engage shoes with wheel cylinder connecting links and install hold-down pin, cup, and spring on primary brake shoe.

(NOTE: Maroon primary and blue secondary hold-down springs are used on the rear brake assemblies.)

21. Position actuating lever and pawl so that actuating lever is on top of secondary brake shoe. Secure with hold-down pin, sleeve, spring, and cup.

22. Install anchor plate, link, and secondary brake shoe retracting spring (yellow). For easiest installation, first connect spring to link then install link on anchor, using brake Spring Remover and Installer, J-8049.

23. Install pawl return spring. Make certain that star wheel engages pawl.

24. Install primary brake shoe retracting spring (red) using Spring Installer, J-8049.

25. Perform preliminary service brake adjustment as described in Note 7.

26. Install rear brake drums on rear axle shaft flange and secure with screw.

27. Install wheels on brake drums. Tighten wheel mounting nuts to 130 foot-pounds.

*(See CAUTION page 5-8 prior to Note 6.)*

28. Adjust parking brake as described in Note 8.

## 18. Machining Brake Drums

### a. Warped or Scored

Brake drums should be carefully checked to see if they have become warped or scored excessively. If they appear salvageable and if suitable equipment is available, they can be machined.

Drum machining is a precision operation. Equipment used for this purpose must be capable of maintaining the close limits specified. Be sure to install drum in the machining equipment correctly and to check runout of lathe spindle to insure accuracy of final machining operation. Inside drum diameter must not be machined over 12.060 inches on all cars except the Eldorado or 11.060 inches on the Eldorado. Should brake drums be machined too thin, the intense heat that develops under severe driving conditions will cause them to distort, crack or warp.

In addition, the specifications listed on page 5-31 for all cars except the Eldorado or page 5-44 for the Eldorado must be held.

Replacement brake drums supplied by your servicing Parts Warehouses are machine-finished at the factory before being shipped. They do not require any further finishing before installation, but they must be thoroughly cleaned with a non-oil base solvent to remove all traces of the oil or grease used for rust-proofing during storage and transit. Do not machine drums to roughen the braking surface. Use coarse emery cloth for this purpose.

### b. Brake Shudder (All Except 693)

Brake shudder may be experienced during light pedal application just as the car is braked to a stop. The shudder, sometimes called "footballing", chatter, or surge, may be caused by improper fit of the rear brake drum to the rear axle shaft, resulting from the mounting face of

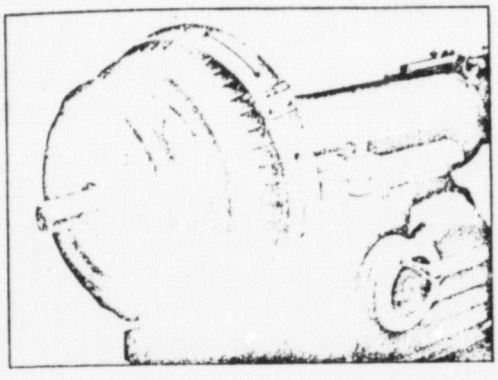


Fig. 5-19 Assembly Mounted on Lathe

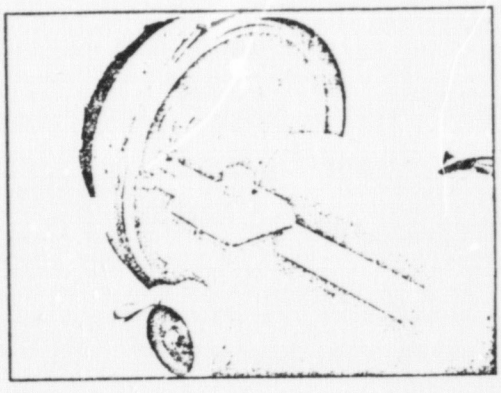


Fig. 5-21 Turning Drum

the drum being out-of-flat.

The out-of-flatness and resultant roughness or "footballing" condition of the rear brake drums can usually be eliminated by turning the suspected drum while it is clamped between a front wheel hub and a wheel spider assembly. (Fig. 5-19)

The entire procedure for drum-turning is as follows:

1. Wipe drum inner mounting surface and front hub surface clean of all metal chips, dust or foreign matter.
2. Install drum causing roughness or shudder between front hub, and wheel spider section, Fig. 5-20 securing with five wheel attaching nuts. Torque nuts to 50 foot-pounds, using a criss-cross pattern of tightening.
3. Turn drum on a lathe in usual manner that a front drum would be turned, Fig. 5-21.
4. After turning drum, unbolt assembly and remove drum. Drum is now ready for installation on car and roadtesting to confirm correction of brake roughness or shudder.

This procedure can be used for all Cadillac rear drums that exhibit brake shudder, and all past model front drums regardless of the make of drum.

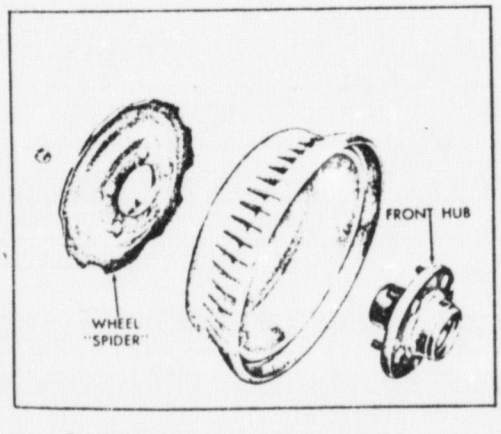



Fig. 5-20 Assembling Spider & Hub To Drum

(NOTE: Front drums of past models have the hub assembled so only the wheel spider need be mounted on these drums before turning.)

Though the front wheel, tire, hub and drum of past models can be removed from the car as an assembly and turned as an assembly on some lathes, it is recommended the tire and wheel assembly be removed from the drum, and the wheel spider be installed before turning. This permits greater ease of handling and places less weight on the drum lathe spindle bearings.

## 19. Wheel Cylinder Servicing

### a. Removal

1. Raise car and remove wheel and brake drum. Blow out dust and dirt from drum and linings.
2. Disconnect hydraulic brake piping from wheel cylinder.
3. Remove brake shoe retracting springs and link.
4. Remove two screws holding wheel cylinder to backing plate.
5. Disengage wheel cylinder connecting links from brake shoes and remove wheel cylinder.

*CAUTION: Be sure brake fluid does not drip on brake linings.*

### b. Disassembly (Fig. 5-22)

1. Remove connecting links and rubber boots from ends of wheel cylinder.
2. Slide pistons and piston cups from either end of cylinder.
3. Remove piston cups, spring and expander assembly.
4. Remove bleeder screw assembly.

### c. Cleaning and Parts Replacement

With clean hands, wash all parts except pistons in clean alcohol. Wipe pistons with clean dry cloth. Inspect surface of cylinder bore and hydraulic passages. Replace wheel cylinder if any obstructions are observed in holes or if there are any nicks or burrs in bore.

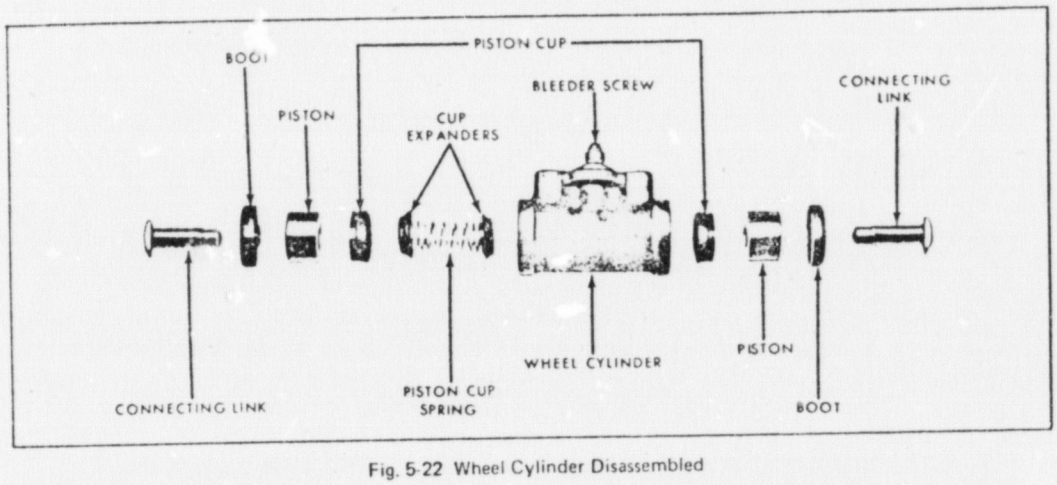



Fig. 5-22 Wheel Cylinder Disassembled

If it is necessary to replace any of the wheel cylinder assembly parts, refer to parts book for replacement parts.

### d. Assembly (Fig. 5-22)

1. Install bleeder screw assembly.
2. Install piston cup in one end of cylinder with lip toward center, and install piston with flat side toward cup.
3. Install rubber boot into end of wheel cylinder.
4. Install spring and expander assembly.
5. Install other piston cup, lip toward center. Install piston, flat side toward cup.
6. Install remaining rubber boot into end of cylinder.

### e. Installation

1. Position wheel cylinder on brake backing plate, slipping cylinder-to-shoe connecting links in place at same time.
2. Install two screws holding wheel cylinder to backing plate. Tighten to 15 foot-pounds maximum torque.

*(See CAUTION on page 5-8 prior to Note 6.)*

3. Install brake shoe retracting springs and link.

(NOTE: Avoid handling friction surfaces of drums and linings.)

4. Connect brake piping to wheel cylinders.
5. Install brake drum and wheel assembly.
6. Bleed all brakes as described in Note 6.

## 20. Parking Brake Assembly

### a. Removal

1. Remove steering column lower cover as explained in Section 12, Note 41a.
2. Place parking brake pedal in release position. Set transmission shift lever in Park position.
3. Working underneath car, remove equalizer nut and washer and separate cable stud from equalizer.
4. Disconnect parking brake vacuum hose at cylinder.
5. Position carpet and left cowl kick-pad out of the way.
6. Working from under hood remove two parking brake assembly-to-cowl mounting nuts.
7. Remove one parking brake assembly-to-instrument panel mounting nut and move assembly away from cowl.
8. Position brake pedal lever so that clevis on parking brake assembly is exposed, and remove brake cable end from clevis.

### b. Installation

1. Position parking brake pedal so that clevis is exposed, and attach parking brake cable to clevis on parking brake assembly.
2. Install parking brake assembly and secure to cowl with two mounting nuts.
3. Install one parking brake assembly-to-instrument panel mounting nut.
4. Connect hose to parking brake vacuum cylinder.
5. Replace cowl kick-pad and carpet.
6. Insert cable stud through equalizer, making sure the center cable is properly routed through equalizer and secured at C-shaped clamp, Fig. 5-23.
7. Install washer and equalizer nut.
8. Adjust parking brake as described in Note 8.
9. Check operation of automatic release.
10. Install steering column lower cover, as explained in Section 12, Note 41b.

## 21. Parking Brake Vacuum Diaphragm

### a. Removal

1. Remove parking brake assembly as described in Note 20a.

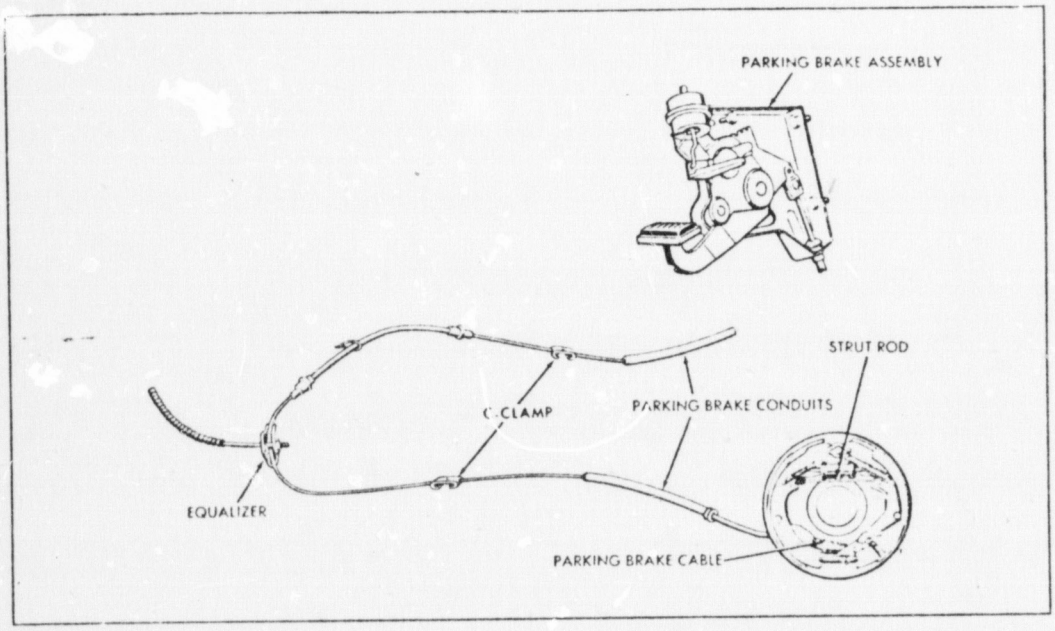



Fig. 5-23 Parking Brake Linkage

2. Drill out one rivet that retains cylinder and bracket to parking brake assembly.
3. Detach link that connects cylinder to manual release lever and remove cylinder.

### b. Installation

1. Position cylinder and bracket on parking brake assembly and secure with one rivet or bolt and nut.
2. Secure link to manual release lever.
3. Install parking brake assembly as described in Note 20b.
4. Test lock and automatic release operations with engine running in Neutral and Drive ranges.

(NOTE: Parking brake should release in any drive range with engine running, and should remain engaged in Neutral and Park with engine running.)

## 22. Parking Brake Cables (Fig. 5-23)

### a. Removal (Front Cable)

1. Release parking brake.
2. Disconnect cable stud at equalizer by removing equalizer nut and washer and separating cable stud from equalizer.
3. Remove U-shaped retainer at frame.
4. Remove U-shaped retainer at pedal assembly.
5. Remove cable end from parking brake assembly clevis.
6. Pull cable through hole in frame and remove from car.

### b. Installation (Front Cable)

1. Insert cable through hole in body.
2. Install cable end into clevis in pedal assembly.
3. Install U-shaped retainer at pedal assembly.
4. Install cable grommet into hole in body.
5. Insert cable through hole in frame.
6. Install U-shaped retainer.
7. Connect cable stud at equalizer by installing washer and nut.
8. Check operation of parking brake system and adjust if necessary as outlined in Note 8.

### c. Removal – Center Cable

1. Release parking brake.
2. Remove equalizer nut and washer from cable stud and remove equalizer.
3. Remove retainer securing cable conduit at cross member and remove cable from bracket.
4. Remove wire guide from cross member.
5. Remove retainer from right body bracket and remove cable from bracket.
6. Remove wire guide from left frame side rail.
7. Remove cable from right and left connectors and remove cable.

### d. Installation – Center Cable

1. Install cable in right and left connectors.
2. Install wire guide securing cable to left frame side rail.
3. Install cable conduit in right body bracket and secure with retainer.

4. Install wire guide securing cable conduit at cross member.

5. Install cable conduit in bracket at cross member and secure with retainer.

6. Install cable in equalizer and secure to cable stud with nut and washer.

7. Check operation of parking brake and adjust if necessary as described in Note 8.

### e. Removal – Rear Cables (All Except Eldorado)

1. Release parking brake.

2. Raise rear of car and place on jack stands.

3. Remove rear wheel and drum on same side of car as parking brake cable being replaced.

4. Remove equalizer nut and washer, and separate equalizer from front cable stud.

5. Remove end of cable being replaced from C-clamp.

6. Remove clip securing cable to control arm bracket and remove cable from bracket by pulling rearward.

7. Remove two screws securing parking brake cable clamp to brake backing plate.

8. Remove pawl spring and pawl lever from actuating lever.

9. Remove cable end from operating lever, and remove cable from backing plate.

### f. Installation–Rear Cables (All Except 693)

1. Route cable end through rear of backing plate and install on operating lever.

2. Install pawl lever and pawl spring.

3. Position parking brake cable clamp against backing plate, securing with two screws. Tighten screws to 11 foot-pounds maximum torque.

*CAUTION: Check operation of cable and brake shoes by pulling on front end of cable.*

4. Route cable over top of rear suspension lower control arms.

5. Insert cable through hole in control arm bracket and secure with clip.

6. Install cable end in C-shaped clamp.

7. Insert front cable stud through equalizer hole and install equalizer washer and nut.

8. Install rear drum and wheel.

9. Adjust parking brake as described in Note 8.

## HYDRAULIC LINES

### 23. Brake Combination Valve (Except Eldorado)

#### a. Removal

1. Disconnect wiring connector from valve.

2. Disconnect three brake pipes from top and one from front of valve.

3. Raise car and disconnect remaining brake pipe from bottom of valve.

4. Remove two bolts securing valve to frame and remove valve.

#### b. Installation

1. Position valve to frame and secure with two bolts.

2. Install brake pipe to bottom of valve.

3. Lower car.

4. Install one brake pipe to front of valve and three on top.

5. Connect wiring connector to valve.

6. Bleed brakes as described in Note 6.

(NOTE: When replacing a combination valve, rear brake bleeding can be accomplished by allowing brake fluid to flow from the rear brake pipe nut at the valve. Back off this nut one turn and catch fluid flow in a cloth or a container until air is eliminated.

The front brakes should be bled at the calipers in the usual manner. Then, before driving car be sure a firm pedal is obtained.)

### 24. Servicing Hydraulic Brake Hoses and Piping—(All Except Eldorado, Fig. 5-24)

The brake system should be checked visually each time the car is lubricated. When the car is raised on a lift for lubrication, brake lines, hoses, and cables should be inspected for proper attachment, leaks, cracks, chafing, deterioration, etc.

The brake hoses should be carefully inspected for cracks in the rubber cover (360° around) at either end of the hose near the fittings by flexing the hose while inspecting it. Adequate lighting and a mirror are essential tools for a good inspection. This inspection is made easier by steering the wheels to a full turn and/or removing the front wheels. If any cracks, chafing, or leaks of the brake hose are detected, the brake hose should be replaced.

#### a. Removal–Hydraulic Brake Hose (Front Wheels)

1. Disconnect steel brake line from hose. Cap fitting to prevent dirt from entering brake line.

2. Remove U-shaped retainer from hose fitting and withdraw hose from frame support bracket.

3. Turn hose fitting out of caliper inlet and remove copper gasket. Discard gasket. If hose is to be reinstalled, cover end fittings to prevent dirt from entering hose.

#### b. Installation–Hydraulic Brake Hoses (Front Wheels)

1. Install new copper gasket on caliper end of hose

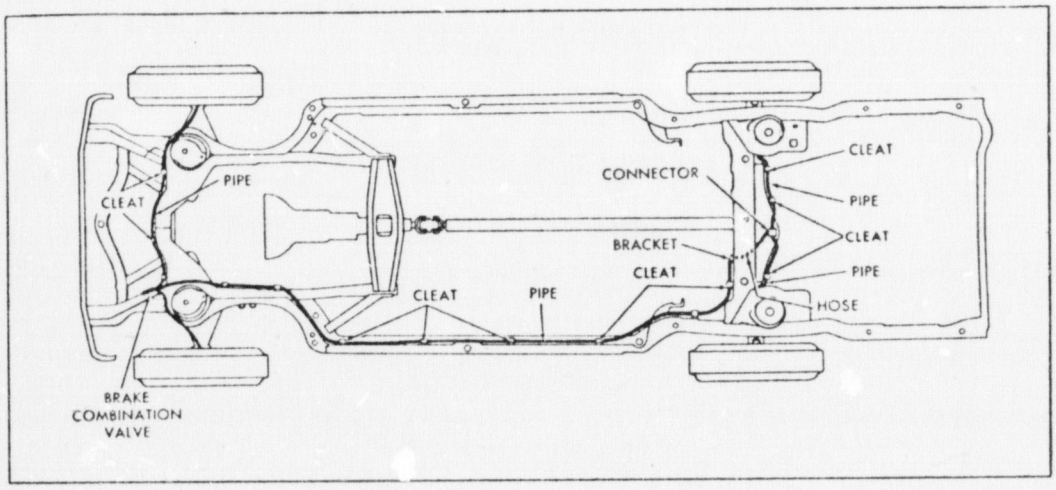



Fig. 5-24 Hydraulic Brake Lines

(male end). Tighten hose in caliper inlet to 30 foot-pounds maximum torque.

*CAUTION: Never tighten hose in caliper inlet with hose attached at frame ends as this will twist the hose.*

2. With suspension in normal position (front wheels straight ahead) pass female end of hose through frame support bracket, allowing hose to seek its own position. Insert hex of hose fitting into the 12-point hole in support bracket in position that will result in least twist in hose.

(NOTE: Do not twist hose any more than necessary during this operation as its natural curvature is essential to maintain proper hose-to-suspension clearance through full movement of suspension and steering parts.)

3. Install U-shaped retainer to secure hose in frame support bracket.

4. Inspect by turning steering from stop-to-stop while observing hose position be sure that hose does not touch other parts at any time during steering travel. If contact does occur, remove hose retainer and rotate female hose end in support bracket one or two points in appropriate direction, replace retainer, and reinspect.

5. Place steel tube connector nut in hose fitting and tighten to 20 foot-pounds maximum torque.

6. Bleed all brakes as outlined in Note 6.

### c. Removal--Hydraulic Brake Hose (Rear Wheels

1. Disconnect brake pipes from hose. Cap pipes to prevent entry of dirt or foreign matter into system.

2. Remove retainer securing forward end of hose to bracket.

3. Remove screw securing hose to axle bracket.

### d. Installation--Hydraulic Brake Hose (Rear Wheels)

1. Thread rear axle pipes into hose.

2. Install brake hose mounting screw and torque to 12 foot-pounds.

3. Pass forward end of hose through mounting hole in frame allowing hose to seek its own position. Insert barrel end of hose fitting into barrel hole in mounting bracket and install retainer.

4. Remove line caps and tighten pipe nuts to 20 foot-pounds maximum torque.

5. Bleed brakes as described in Note 6.

### e. Removal--Hydraulic Brake Piping (Rear Wheels)

1. Disconnect steel brake piping at rear wheel cylinder fitting. Cap fitting to prevent dirt from entering wheel cylinder.

2. Disconnect brake piping at brake hose on axle housing.

3. Unbend from welded retainer(s) on axle housing, and remove piping.

4. Remove screw securing pipe cleat to upper control arm bracket (R.H. only), remove piping.

### f. Installation--Hydraulic Brake Piping (Rear Wheels)

1. Install steel piping on welded retainers.

2. Connect piping at brake hose and tighten to 20 foot-pounds maximum torque.

3. Connect piping at wheel cylinder fitting, tightening to 20 foot-pounds maximum torque.

4. Bend welded retainer(s) over piping enough to secure, being careful not to damage brake piping.

5. Install screw and pipe cleat securing piping to R.H. upper control arm bracket.

6. Bleed all brakes as outlined in Note 6.

## 25. Hydraulic Brake Tubing

Hydraulic brake tubing is a double layer annealed steel terne plate tubing which resists corrosion and has the physical strength to stand up under the high pres-

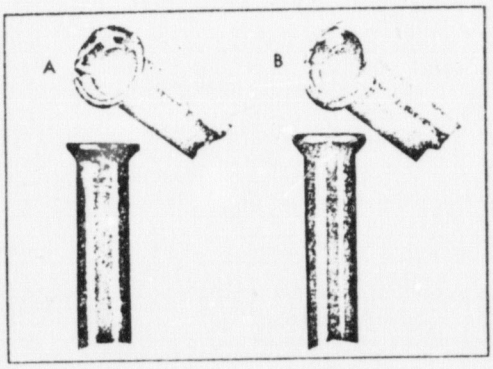



Fig. 5-25 Single and Double Lap Flair

sures which are developed when applying the brakes. In making up hydraulic brake pipes, it is recommended that Flaring Tool No. J-23530 be used to double-lap flare the ends of the tubing. Unless the tubing is properly flared, the connections will leak and the brakes will become ineffective.

*CAUTION: When necessary to replace brake tubing, always use special steel tubing which is designed to withstand high pressure and resist corrosion. Ordinary copper tubing is not satisfactory and should not be used.*

This safety steel tubing must be double-lap flared at the ends in order to produce a strong leak-proof joint.

Figure 5-25 shows two pieces of tubing, one with single-lap flare "A" and the other with double-lap flare "B". It will be noted that the single-lap flare in "A" split the tubing while the one shown in "B" is well-formed and unbroken due to the reinforcement of the double wall.

The following procedure should be followed in making up hydraulic brake pipes.

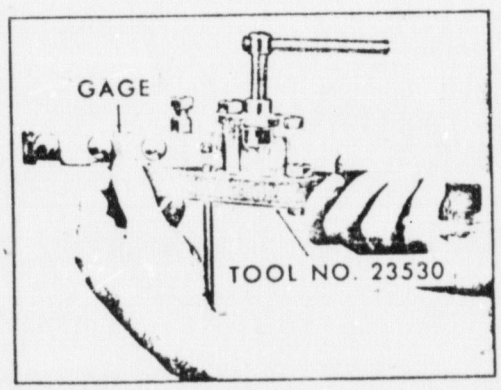



Fig. 5-26 Placing Tubing in Tool

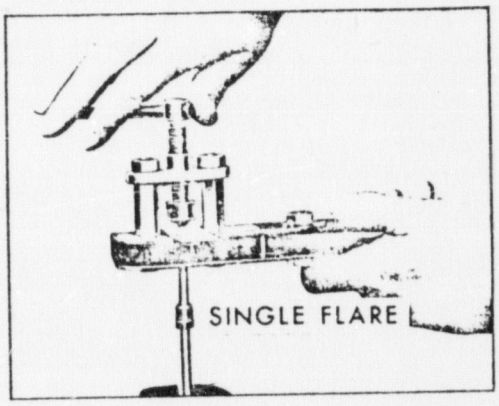



Fig. 5-27 Preparing for Double Lap Flare

## 26. Double Lap Flaring

1. Cut the tubing to the desired length.
2. Cut end square and clean burrs from inside and outside of tubing to be flared.
3. Using Tool No. J-23530, unscrew compression screw until swivel cone is at its highest point; swing strap to one side.
4. Open lever handle so it is at right angle to rest of tool, and revolve hexagonal tube clamps to accommodate tubing. (Selection of six sizes).
5. Be sure tubing nut is properly placed on tubing. Insert end of tube between two blocks until level with top of gage, Fig. 5-26.
6. Insert proper pin of gage into tubing and swing strap back in closed position. Tighten compression screw until gage bottoms on tool, Fig. 5-27, then unscrew compression screw and swing strap to one side. Remove gage.
7. Swing strap back in closed position, then tighten compression screw to flare cone downward to complete double-lap flare, Fig. 5-28.
8. Unscrew compression screw and open smaller lever handle to remove tubing.

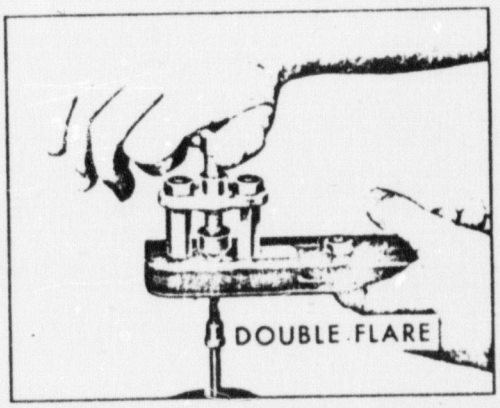



Fig. 5-28 Completing Double Lap Flair

9. Inspect flared ends for splits, cracks, pits or excessive out of round which may cause leaks.

10. Blow tubing out with dry compressed air to remove any foreign objects.

## 27. Power Brake Unit

### a. Removal

1. Disconnect hydraulic brake lines from master cylinder, Fig. 5-29. Cap line fittings to prevent dirt from entering brake lines.

2. Disconnect vacuum hose from vacuum check valve on power head.

3. Remove steering column lower cover as described in Section 12, Note 41a.

4. Remove retainer and washer that attach power unit push rod to brake pedal arm.

5. Remove any three of four nuts securing power unit to cowl and loosen fourth nut.

6. Working in engine compartment, free power unit from cowl.

7. Disconnect brake unit push rod from brake pedal arm. Remove spring spacer from brake pedal arm.

8. Remove remaining nut retaining power unit to cowl, and remove power unit gaskets and spacer from engine compartment.

### b. Installation

1. Position power unit gaskets and spacer to cowl.

2. Working inside passenger compartment, loosely install four nuts retaining power unit to cowl.

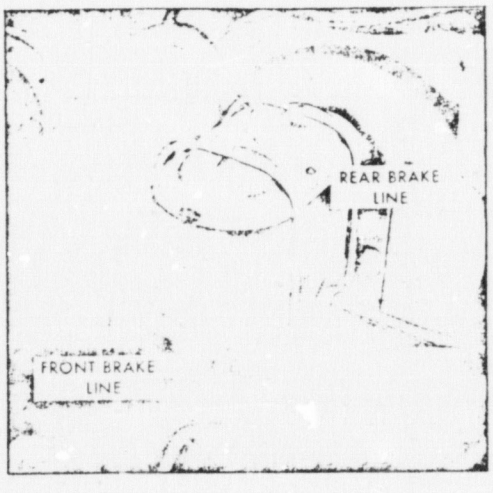



Fig. 5-29 Power Brake Unit

3. Install spring spacer, push rod and washer on brake pedal arm and secure with retainer.

4. Tighten four nuts that hold the power unit to 16 foot-pounds.

*(See CAUTION page 5-8 prior to Note 6.)*

5. Install steering column lower cover as described in Section 12, Note 41b.

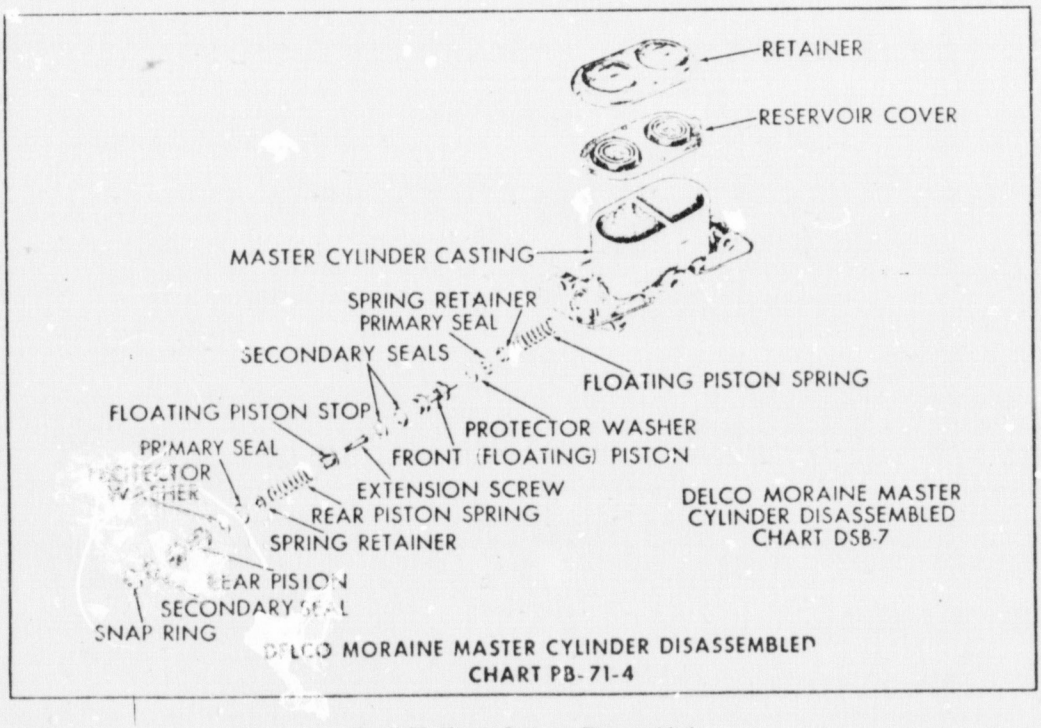



Fig. 5-30 Master Cylinder Disassembled

6. Connect vacuum hose to check valve on power unit.

7. Secure hydraulic brake lines to master cylinder to 20 foot-pounds maximum.

8. Bleed brakes as described in Note 6.

## 28. Master Cylinder Disassembly, Cleaning, Inspection and Assembly (Fig. 5-30)

### a. Disassembly

(NOTE: If trouble has been traced to hydraulic system, master cylinder may be removed from power head without removing power head from car. Area surrounding master cylinder mounting surface must be kept clean.)

1. Disconnect and cap front and rear brake lines if not done previously.

2. Remove two self-locking nuts that hold master cylinder to power head and remove master cylinder.

3. Pry bale type retainers off of reservoir cover, and remove reservoir cover and seal. Drain brake fluid from reservoirs.

4. Remove seal from reservoir cover.

5. Remove floating piston stop bolt from front fluid reservoir.

6. Remove lock ring from open end of master cylinder and remove rear piston assembly, Fig. 5-30.

7. Firmly tap master cylinder on a block of wood until floating piston drops in bore and remove front (floating) piston assembly, retainer and spring.

*CAUTION: Check progress of floating piston dropping in bore to avoid striking piston on wood. If floating piston sticks in bore, blow dry compressed air through front brake outlet hole.*

8. Place master cylinder in vise with outlet holes up being careful not to damage reservoir seal surface of casting.

9. Remove the primary seal, primary seal protector and secondary seals from the front (floating) piston.

10. Remove piston extension screw from center of floating piston stop and remove floating piston stop and spring from rear piston.

(NOTE: If necessary, grasp the unfinished piston body immediately under flange containing holes with a pair of pliers to remove piston extension screw.)

11. Remove spring retainer, primary seal, primary seal protector and secondary seal from the rear piston.

### b. Cleaning and Inspection

1. Inspect master cylinder bore for scoring, pitting or etching. Any of these will require replacement of master cylinder casting.

2. Examine fluid reservoir for foreign matter, and check all passages for restrictions. If there is any suspicion of contamination or evidence of corrosion, completely flush hydraulic system, using clean brake fluid.

(NOTE: A grease like silicone substance may be found inside the brake master cylinder when it is being overhauled. This substance is used by the manufacturer as a lubricant to provide smooth brake actuation. It is a normal condition and need not be cleaned out of the master cylinder before reassembly.)

3. Inspect floating piston for severe scoring, pitting, or distortion. Any of these will require replacement of master cylinder assembly.

(NOTE: Floating piston may show a wear pattern; however, do not replace assembly unless wear is severe.)

4. Thoroughly wash all parts (except the inside of master cylinder) in clean alcohol, including new parts to be used in assembly of master cylinder but do not wash silicone out of master cylinder.

*CAUTION: Use of gasoline, kerosene, anti-freeze, or any cleaner with even a trace of mineral oil will damage rubber parts.*

5. Use air hose to blow out all passages, orifices, and valve holes. Air dry and place cleaned parts on clean paper or lint-free cloth.

6. When overhauling a master cylinder, use all parts furnished in master cylinder repair kit.

### c. Assembly

Be sure all parts are clean before assembling master cylinder. Do not let grease or mineral oil come in contact with any rubber parts.

1. Lubricate rubber parts with clean brake fluid.

2. Install new secondary seal in center groove of floating piston. Lip of seal should face compensating holes in opposite end of piston.

3. Install new secondary seal in groove at end of floating piston, back-to-back with secondary seal in center groove, Fig. 5-30 so that lip faces toward that end.

4. Install primary seal protector and primary seal over end of floating piston opposite secondary seals. Seal protector seats against flange of piston that contains compensating holes, and flat side of seal seats against protector.

5. Install secondary seal in groove on push rod end of rear piston. Lip of seal should face toward compensating holes in opposite end of piston.

6. Install primary seal protector and primary seal on opposite end of rear piston. Seal protector seats against flange of piston that contains compensating holes, and flat side of seal seats against protector.

7. Position spring retainer on one end of rear piston spring and floating piston stop on other end.

8. Position spring assembly on rear piston with spring retainer seated inside lips of primary seal.

9. Insert piston extension screw in center of floating piston stop.

10. Compress primary piston spring and start piston extension screw in hole in end of piston, release spring

and turn down screw. Torque to 7-8 foot-pounds to bottom shoulder on screw against retainer.

11. Position retainer in floating piston spring and position spring assembly on floating piston with retainer seat inside lip of primary seal.

12. Coat master cylinder bore, primary seal and secondary seals on floating piston with clean brake fluid.

13. Position master cylinder casting in vise so that open end of bore is down slightly and install floating piston assembly in bore, spring end first, until assembly bottoms in bore.

14. Reposition master cylinder in vise so that open end of bore is up.

15. Coat primary and secondary seals on rear piston assembly with clean brake fluid and insert assembly into master cylinder bore, spring end first.

16. Pressing downward on rear piston, install lock ring in groove in master cylinder piston.

17. Install floating piston stop bolt in front fluid reservoir, tightening to 3 foot-pounds maximum torque.

18. Install new reservoir seal on reservoir cover, place cover on master cylinder, retaining with bale-type retainers.

19. Install master cylinder on power head, torquing nuts to 20 foot-pounds maximum torque.

20. Install front and rear brake lines, if power head is on car, tightening lines to 15 foot-pounds and bleed brakes as described in Note 6.

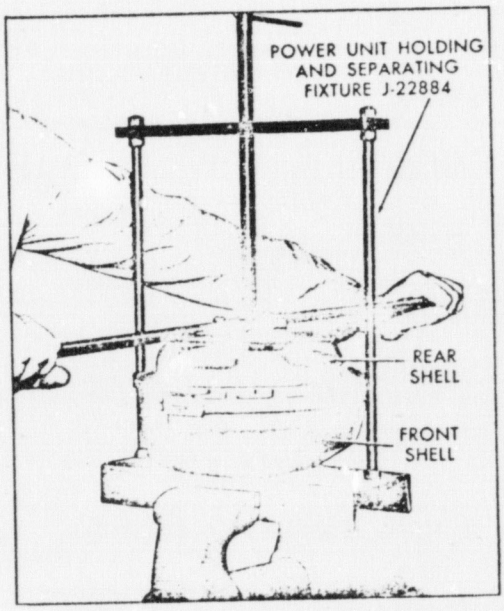



Fig. 5-31 Removing Rear Shell

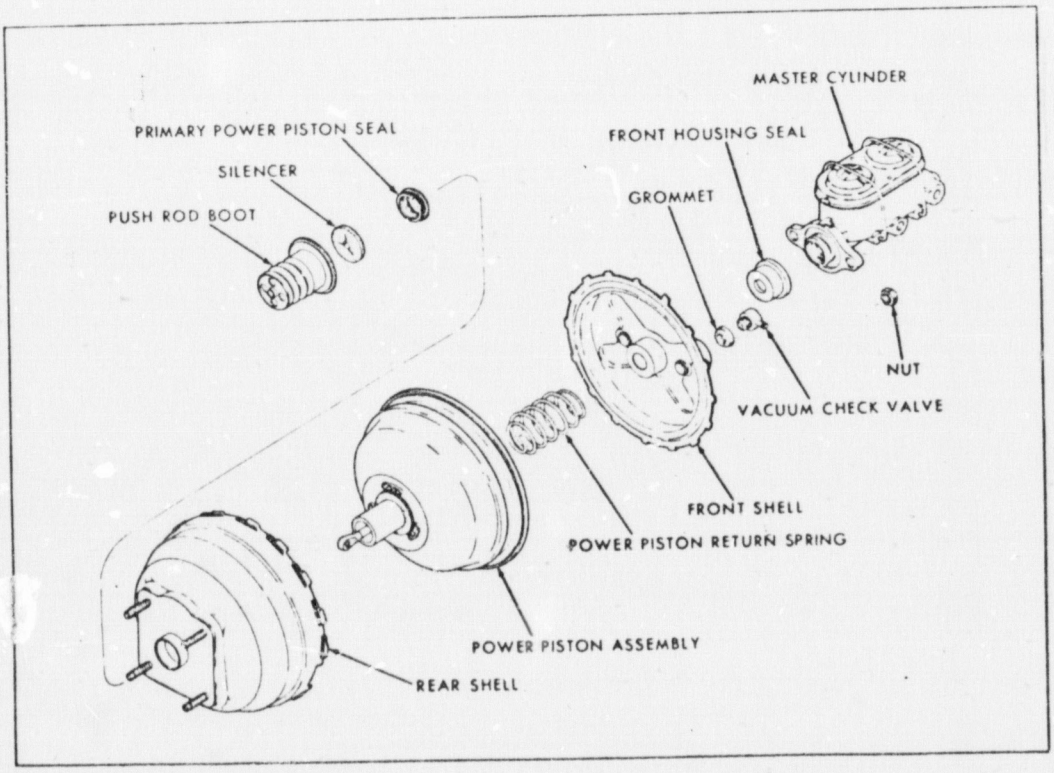



Fig. 5-32 Power Head Disassembled

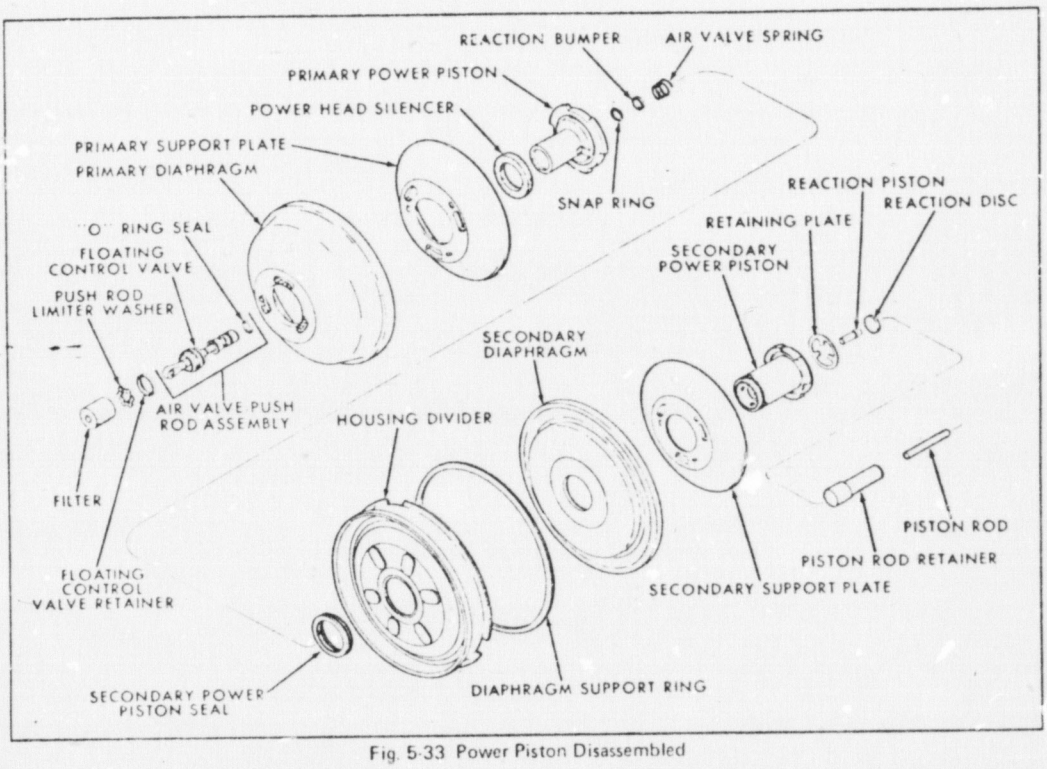



Fig. 5-33 Power Piston Disassembled

## 29. Power Head Disassembly, Cleaning, Inspection and Assembly

### a. Disassembly

(NOTE: Scribe mark on top center of front and rear housings in line with master cylinder reservoir cover to facilitate reassembly.)

1. Remove master cylinder reservoir cover retainers, reservoir cover and diaphragm, and empty brake fluid from reservoirs.

2. Remove two locknuts which hold master cylinder to front housing, and remove master cylinder from its mounting studs. Remove front housing seal from front shell.

(NOTE: If Separating Fixture, J-22884, is not available, use Separator, J-9504. Do not remove master cylinder at this time if J-9504 is to be used.)

3. Secure Power Unit Shell Holding and Separating Fixture, J-22884, and power head, Fig. 5-31. Studs on rear shell engage base of fixture and studs on front shell engage bar of tool with bar bearing against front shell. Secure front shell to bar with two master cylinder lock nuts.

4. Rotate bar counterclockwise and unlock shells.

5. Back off on hold down clamp sufficiently to remove front shell, return spring, retaining plate and piston rod retainer, Fig. 5-32 and 5-33.

*CAUTION: Be careful when separating diaphragms that return spring does not fly out.*

6. Remove vacuum check valve and grommet from front shell.

7. Remove assembly from holding fixture and remove J-22884 from vise.

8. Remove dust boot retainer and boot from rear

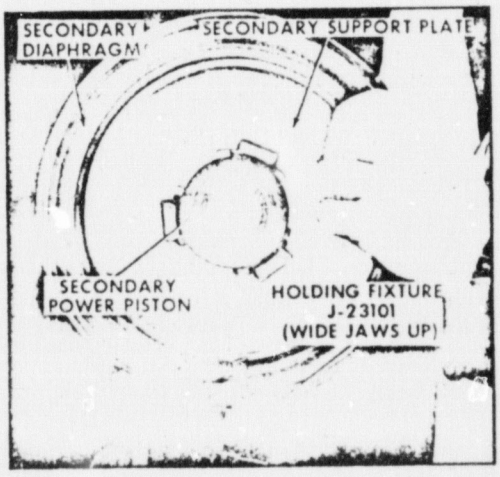



Fig. 5-34 Positioning Secondary Power Piston

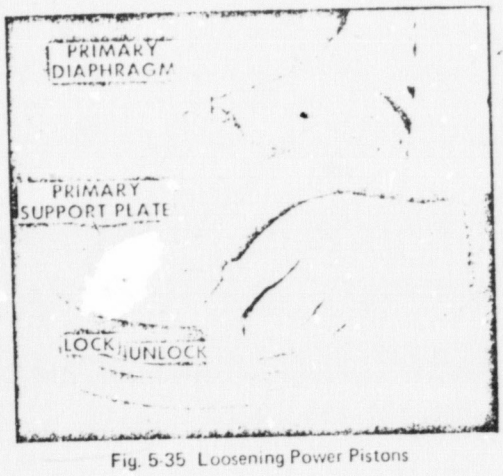



Fig. 5-35 Loosening Power Pistons

housing and push rod. Remove felt silencer from inside the boot.

9. Remove power piston assembly from rear shell and remove primary power piston seal from center opening of rear shell.

10. Lift bead on outside diameter of secondary diaphragm and remove diaphragm support ring, Fig. 5-33.

11. Mount Holding Fixture, J-23101, in a vise with wide jaws up. Position secondary power piston so that two radial slots in piston fit over jaws of tool, Fig. 5-34.

12. Fold back primary diaphragm from outside diameter of primary support plate. Grip edge of support plate and rotate counterclockwise to unscrew primary piston from secondary power piston, Fig. 5-35.

(NOTE: It is possible that primary support plate will unlock from primary piston before primary piston unscrews from secondary piston. If this happens, continue to turn primary support plate counterclockwise. Tabs ("stops") on primary support plate will temporarily lock primary support plate to primary power piston and permit continued counterclockwise rotation to unscrew primary power piston from secondary power piston.)

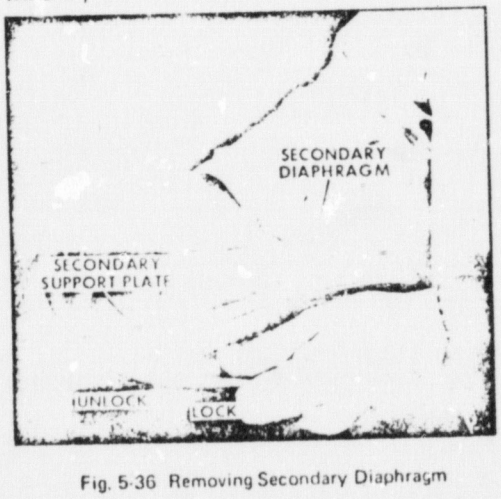



Fig. 5-36 Removing Secondary Diaphragm

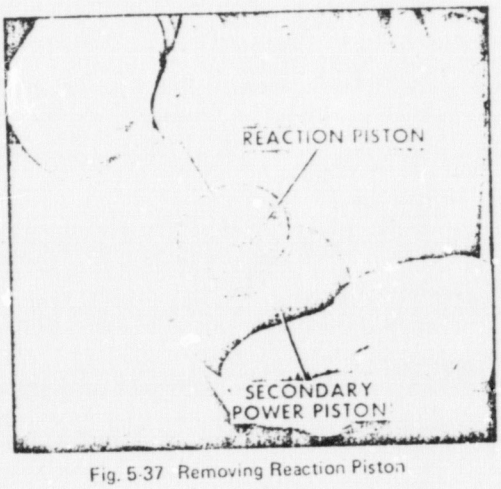



Fig. 5-37 Removing Reaction Piston

13. Remove air valve spring from secondary power piston or end of air valve.

14. Remove housing divider from secondary power piston. Remove secondary power piston seal from housing divider.

15. Secondary power piston should still be positioned on Tool J-23101. Fold back secondary diaphragm from O.D. of secondary support plate. Grip edges of support plate and rotate clockwise to unlock secondary support plate from secondary power piston, Fig. 5-36.

16. Remove secondary diaphragm and support plate and separate.

17. Remove reaction piston and reaction disc from center of secondary power piston by holding it in hand and pushing down on end of reaction piston with a small object, such as a pencil, wooden dowel or metal rod, Fig. 5-37.

18. Mount Tool J-23101 in vise with small jaws up.

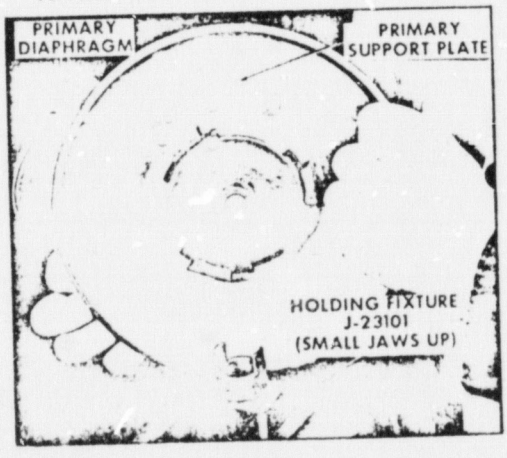



Fig. 5-38 Positioning Primary Power Piston

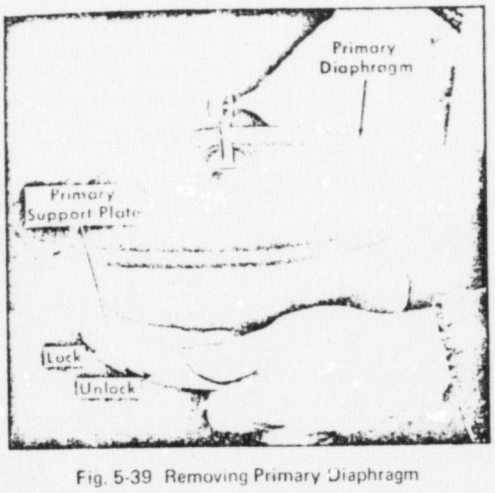



Fig. 5-39 Removing Primary Diaphragm

Position primary power piston so two radial slots in piston fit over jaws of tool, Fig. 5-38.

19. Fold back primary diaphragm from support plate. Grip edge of support plate and rotate in a counterclockwise direction to unlock primary support plate from primary power piston, Fig. 5-39.

20. Remove primary diaphragm from primary support plate.

21. Remove air filter and push rod limiter washer from tubular section of primary power piston, Fig. 5-33.

22. Remove power head silencer from neck of power piston tube.

23. Remove rubber reaction bumper from end of air valve.

24. Clamp eyelet end of air valve push rod in side of vise and using Snap Ring Pliers, J-4880 remove snap ring from air valve, Fig. 5-40.

25. Remove air valve-push rod assembly from tube end of primary power piston by pulling on primary power piston. A considerable force will be required.

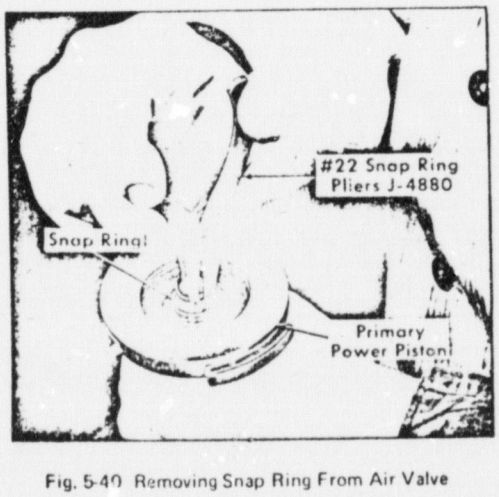



Fig. 5-40 Removing Snap Ring From Air Valve

Removal of air valve push rod assembly will disassemble control valve retainer.

26. Remove "O" ring seal from air valve.

Air valve push rod assembly is serviced as a complete assembly, since floating control valve cannot be removed over end of push rod.

### b. Cleaning and Inspection

1. Thoroughly wash all parts in clean alcohol.

*CAUTION: Use of gasoline, kerosene, anti-freeze or any cleaner with even a trace of mineral oil will damage rubber parts.*

2. Use air hose to blow out all passages, orifices, and valve holes. Air dry and place cleaned parts on clean paper or lint-free cloth.

3. If any rust is found inside front or rear shell, polish clean with crocus cloth or fine emery paper, washing clean afterwards.

4. Inspect front and rear shells for scratches, scores, pits, dents or other damage affecting rolling or sealing of diaphragm or other seals. Small imperfections may be smoothed out with fine crocus cloth.

5. Inspect all original parts, not being replaced by repair kit, for damage, distortion or excessive wear and chips, and replace as necessary.

6. Use all parts furnished in power head repair kit.

### c. Assembly

1. Lubricate "O" ring seal, Fig. 5-33 with silicone lubricant and place on air valve.

2. Wipe a thin film of silicone lubricant on large and small O.D. of floating control valve.

3. If floating control valve needs replacement, it will be necessary to replace complete air valve push rod assembly, since floating control valve is a component part of this assembly and cannot be disassembled from push rod.

4. Place air valve end of air valve push rod assembly into tube of primary power piston. Manually press air valve push rod assembly so that floating control valve bottoms on tube section of primary power piston.

5. Place floating control valve retainer (Fig. 41) on Control Valve Retainer Installer, J-23175. Place over push rod so that closed side of retainer seats on floating control valve. With Installer, J-23175, manually press retainer and floating control valve assembly to seat in primary power piston tube, Fig. 5-42.

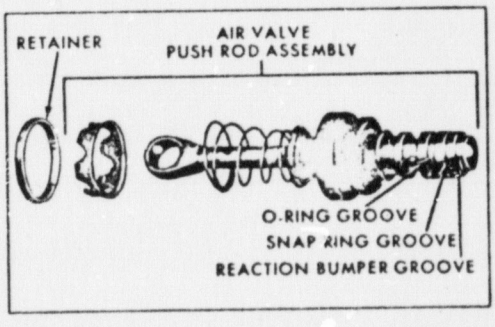



Fig. 5-41 Floating Control Valve

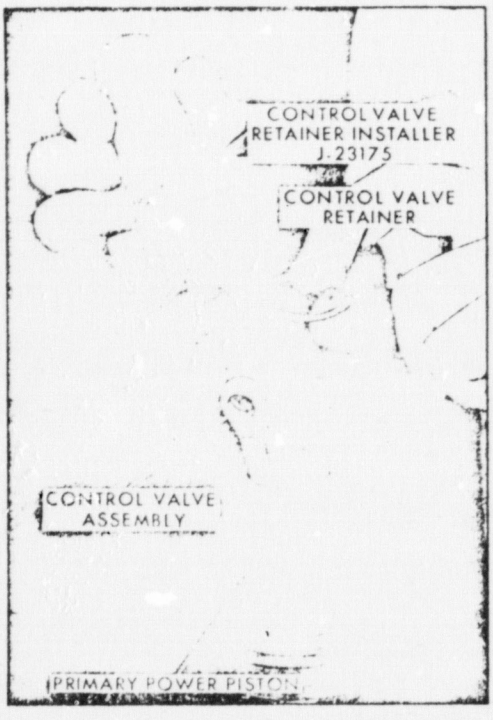



Fig. 5-42 Installing Retainer Ring

6. After floating control valve is seated, place push rod limiter washer over push rod and position on floating control valve, Fig. 5-33.

7. The filter element can now be stretched over push rod eye and pressed into primary power piston tube, Fig. 5-33.

8. Using Snap Ring Pliers, J-4880, place snap ring in its air valve groove, Fig. 5-40.

(NOTE: If snap ring is installed in O-ring groove, power pistons will not thread together all the way and threads may be damaged.)

9. Position rubber reaction bumper on end of air valve.

10. Apply a light film of silicone lubricant to O.D. of rubber reaction disc. Place disc in small cavity of the secondary power piston and push disc down to seat on reaction piston.

11. Assemble primary diaphragm to primary support plate from side of plate opposite locking tangs, Fig. 5-33. Press raised flange on I.D. of diaphragm through center hole of support plate. Be sure edge of support plate center hole fits groove in raised flange of diaphragm. Lubricate diaphragm I.D. and raised surface of flange that fits into a groove in the primary power piston with light coat of silicone lubricant.

12. Mount Holding Fixture, J-23101, in vise, small jaws up. Position primary power piston so two radial slots in piston fit over jaws of tool, Fig. 5-38.

13. Fold primary diaphragm away from O.D. of the primary support plate.

14. Holding edges of the support plate, with the locking tangs down, place primary support plate and diaphragm assembly over tube of primary power piston. Flange on the I.D. of primary diaphragm will fit groove in the primary power piston.

15. Grip edges of primary support plate, press down, and rotate clockwise until tabs on primary power piston contact stops on support plate, Fig. 5-39.

16. Place power head silencer on tube of primary power piston so holes at the base of tube are covered.

17. Apply a very light film of silicone lubricant to O.D. of primary power piston tube.

*CAUTION: Avoid applying excessive lubricant.*

18. Remove primary piston assembly from Tool J-23101 and lay it aside.

19. Assemble secondary diaphragm to secondary support plate from side of support plate opposite locking tangs, Fig. 5-33. Press raised flange on I.D. of diaphragm through center hole of support plate. Be sure edge of support plate center hole fits groove in the raised flange of diaphragm. Apply thin coat of silicone lubricant to I.D. of secondary diaphragm and raised surface of flange (that fits into a groove in the secondary power piston).

20. Mount Tool J-23101 in vise with large jaws up. Position secondary power piston so curved slots in piston fit over jaws of tool, Fig. 5-34. Apply light coat of silicone lubricant to tube of secondary power piston.

21. Fold secondary diaphragm away from O.D. of secondary support plate.

22. Holding edges of the support plate, with locking tangs down, place secondary diaphragm and support plate assembly over tube of secondary power piston. Flange on I.D. of secondary diaphragm will fit secondary piston groove.

23. Grip edges of secondary support plate, press down, and rotate counterclockwise until tabs on secondary power piston contact stops on support plate, Fig. 5-35. Fold secondary diaphragm back into position on secondary support plate. Leave secondary power piston assembly on Tool J-23101 in vise.

24. Apply light coat of talcum powder or silicone lubricant to bead on O.D. of secondary diaphragm. This will facilitate assembly of front and rear housings.

25. Place secondary diaphragm support ring on the secondary power piston assembly so it rests on edge of diaphragm.

26. Hold the housing divider so the six impressions on middle of divider stick up. Install seal so part number can be read from this side.

27. Lubricate I.D. of secondary seal with silicone lubricant.

28. Position Secondary Seal Protector Tool, J-23188, on threaded end of secondary power piston, Fig. 5-43.

29. Hold the housing divider so the six impressions on middle of divider stick up. Press divider down over tool and onto secondary power piston tube where it will rest against the diaphragm support ring. Remove Seal Protector, J-23188, from secondary power piston; however, do not remove secondary power piston sub-

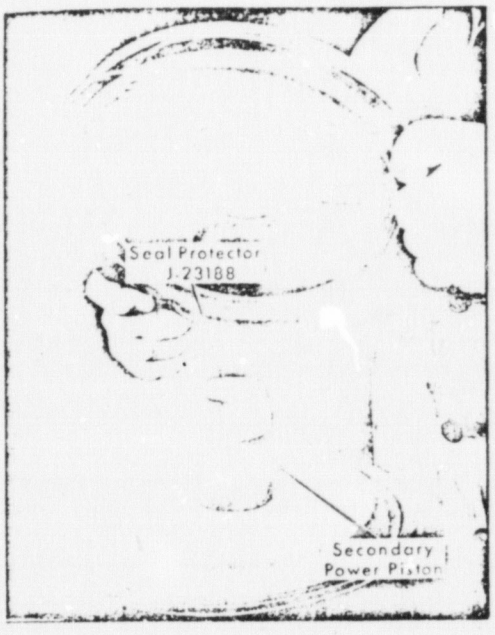



Fig. 5-43 Installing Housing Divider

assembly from Holding Fixture, J-23101.

30. Pick up primary power piston assembly and position small end of air valve return spring on air valve so it contacts air valve retaining ring.

31. Fold primary diaphragm away from O.D. of primary support plate.

32. Position primary power piston on tubular portion of secondary power piston, making sure small end of air valve return spring seats on air valve snap ring.

33. Grip edge of primary support plate, press down, and start threads on secondary power piston into threaded portion of primary power piston by rotating clockwise, Fig. 5-35.

34. Continue to tighten primary power piston until it is securely attached to secondary power piston.

35. Fold primary diaphragm back into position on primary support plate and pull diaphragm O.D. over formed lip of housing divider. Check to be sure bead on diaphragm is seated evenly around complete circumference.

36. Remove assembly from tool J-23101. Wipe a thin film of silicone lubricant on O.D. of piston rod retainer. Insert master cylinder piston rod retainer into secondary power piston cavity so flat end bottoms against rubber reaction disc in bottom of cavity.

37. Place primary power piston seal in rear housing center hold so formed flange of housing center hole fits groove of primary power piston seal. The part number of seal should show on inside of shell.

38. Coat I.D. of primary power piston seal with thin film of silicone lubricant.

*CAUTION: Avoid applying excessive lubricant.*

39. Mount Power Unit Holding and Separating Fixture, J-22884, in vise and position rear shell on tool so studs fit holes provided in tool.

40. Position power piston return spring over front shell ins[illegible]

41. Assemble power piston to rear shell by pressing primary power piston tube through rear housing seal. Press down until housing divider seats in the rear shell and primary power piston bottoms against shell.

42. Place piston rod retaining plate on end of power piston.

43. Install vacuum check valve grommet in front shell with large diameter outside.

44. Install vacuum check valve.

45. Hold front shell assembly (with mounting studs up) over rear shell. Position front shell so that when tangs on edge of front shell are locked in slots on edge of rear shell, scribe marks on top of shells will be in line.

46. Lower front shell assembly onto rear shell by tightening hold down clamp. Check to be sure piston rod retainer goes through center of retaining plate on power piston return spring. Retaining plate and power piston spring must seat in depression in face of secondary power piston. Check to be sure bead on O.D. of secondary diaphragm is positioned between edges of shells.

47. Continue to tighten clamp on front shell and fit tangs in appropriate slots on rear shell.

48. Rotate bar clockwise into locked position and remove power head from Holding Fixture, J-22884.

49. Place silencer in closed end of power head boot. Stretch boot over push rod and over flange in center of rear housing and install boot retainer.

50. Place power head assembly in vise with front shell facing up. Insert master cylinder piston rod, flat end first, into piston rod retainer.

51. Press down on master cylinder piston rod to be sure it is properly seated.

(NOTE: Remove front housing seal to assure that no vacuum is in power head while gaging.)

52. Place Gage, J-22647, over piston rod in a position which will allow gage to be slipped to left or right without contacting studs. (Fig. 5-44)

The center section of gage has two levels. The piston

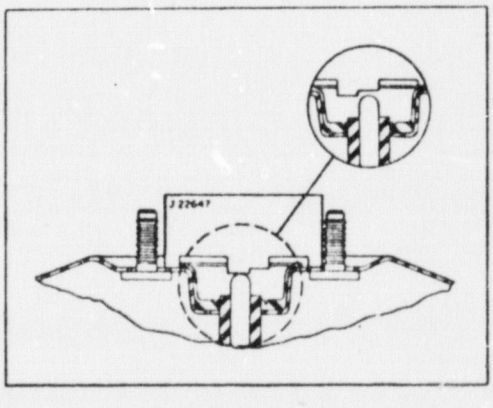



Fig. 5-44 Gaging Push Rod

rod should always contact the long section (low level) of gage. The piston rod should never contact the short section (high level) of gage, Fig. 5-44. Move gage from side to side to check piston rod height.

Any variation beyond these two limits must be compensated for by obtaining an adjustable piston rod from your servicing Parts Distribution Center and adjusting self-locking screw to meet gaging specifications.

53. Wipe a thin film of silicone lubricant on the I.D. of front housing seal and position seal in housing depression.

54. Install master cylinder assembly on front housing, positioning cylinder on mounting studs so top of master cylinder reservoir is toward scribe marks on housing. Assemble locknuts on studs and torque to 20 foot-pounds.

## SPECIFICATIONS

| Item | | All Series Except Eldorado |
|---|---|---|
| Swept Braking Area (in square inches) | | |
| Front | | 241 |
| Rear | | 189 |
| Lining Area (in square inches) | | |
| Front | | 42 |
| Rear | | 117 |
| Wheel Cylinder Bore | | |
| Rear – Except Commercial | | 15/16" |
| Rear – Commercial | | 1" |
| Drums (inside diameter) | | 12.00" |
| Remachined Drum Diameter (maximum) | | 12.060" |
| Worn Drum Diameter (maximum) | | 12.090" |
| Variations of Inside Drum Diameter (maximum) | | .0015" |
| Run-Out of Inside Drum Diameter (maximum) | | .005" |
| Disc Thickness – minimum – Refinished | | 1.220" |
| – minimum – Worn | | 1.215" |
| Clearance Between Secondary Linings and Drums | | .010" – .030" |
| Lateral Run-Out of Disc | | .005" |
| Flatness and Parallelism Between Frictional Surfaces of Disc | | .0007" |
| Lining Size (length, width, thickness in inches) | | |
| Front | Inner Shoe | 5.4 x 1.93 x .43 |
| | Outer Shoe | 5.4 x 1.93 x .41 |
| Rear Primary | | 11.00 x 2.50 x .24 |
| Rear Secondary | | 12.36 x 2.50 x .26 |
| Lining to Shoe Attachment Method | | Rivets |
| Brake Combination Valve | | |
| Front Brake Cut-in Pressure | | 130 psi |
| Front Brake Blend Pressure | | 650 psi |
| Rear Brake Proportioning Pressure – (except Limousine and Commercial and Track Master) | | 41% above 350 psi |
| Rear Brake Proportioning Pressure with Track Master (Except Limousine and Commercial) | | 41% above 470 psi |
| Failure Warning Differential Pressure | | 100-300 psi |

## TORQUE SPECIFICATIONS

| Material Number | Application | Size | Foot-Pounds |
|---|---|---|---|
| Special | Pipe Nut to Master Cylinder | 1/2 –20 or 9/16–18 | 25 Max. |
| Special | All Other Brake Pipe Nuts | 3/8 –24, 7/16–24, 1/2 –20 | 20 Max. |
| 260M | Parking Brake Cable Clamps (at Backing Plate) | 5/16–24 | 11 |
| Special | **Brake Hose to Caliper | 7/16–20 | 30 Max. |
| 300M | **Brake Backing Plate to Rear Axle Housing | 7/16–20 | 40 Max. |
| 284M | **Brake Unit to Cowl | 3/8 –16 | 13 |
| 286M | Brake Pedal Pivot Bolt | 7/16–20 | 13 |
| 286M | Master Cylinder to Vacuum Power Head | 3/8 –24 | 20 |
| Special | **Caliper to Steering Knuckle Bolt | Special | 30 |
| Special | Piston Extension Screw | Special | 90* |
| Special | Floating Piston Stop Bolt | 10–24 | 30* |
| | Wheel Mounting Nuts | | 130 |
| | *Inch-Pounds | | |

(NOTE: Refer to back of Manual, Page 16-1 for bolt and nut markings and steel classifications.)

***CAUTION:* *This fastener is is an important attaching part in that it could affect the performance of vital components and systems, and/or could result in major repair expense. It must be replaced with one of the same part number or with an equivalent part if replacement becomes necessary. Do not use a replacement part of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of this part.*

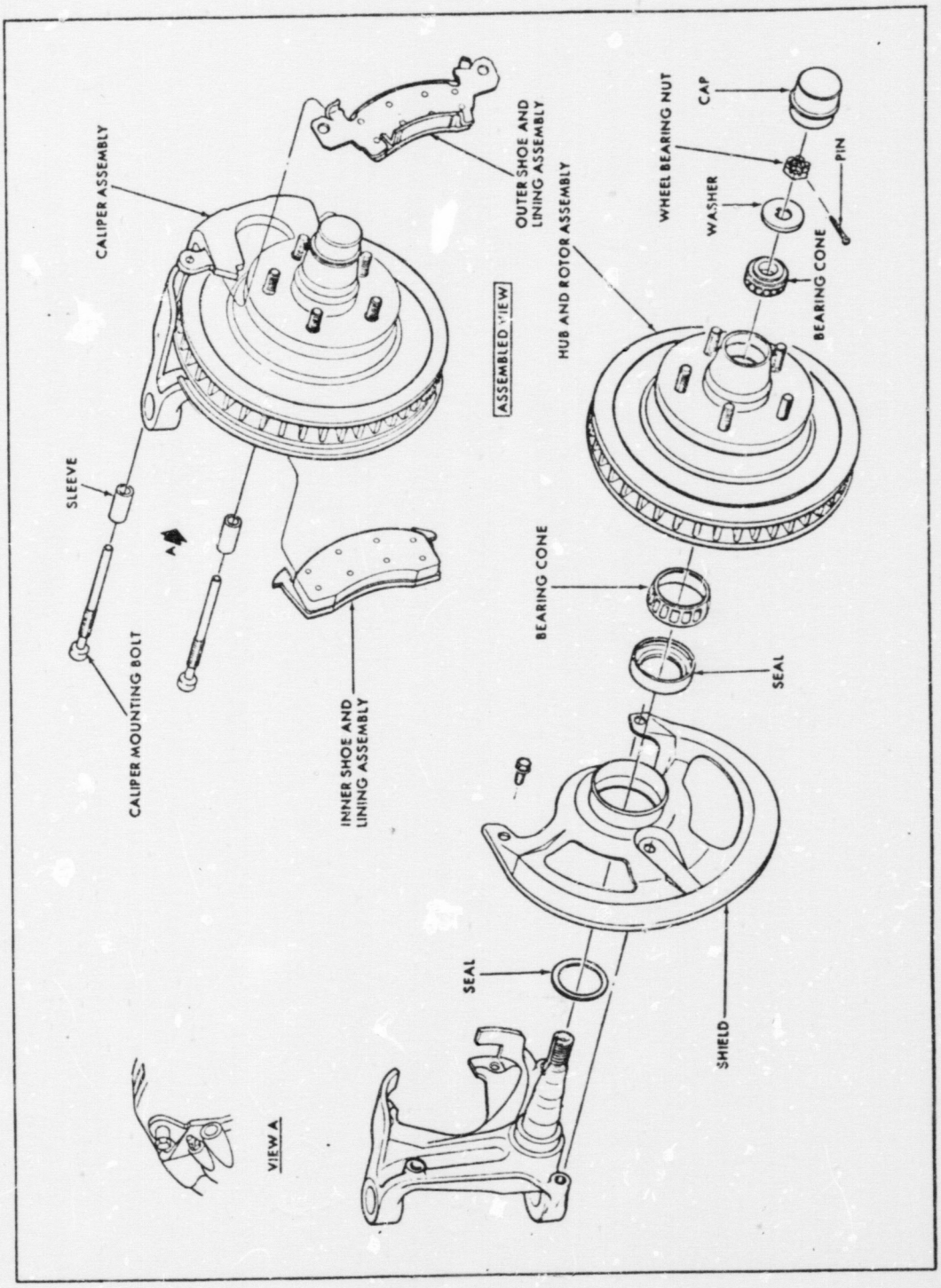



Fig. 5-45 Front Disc Brake

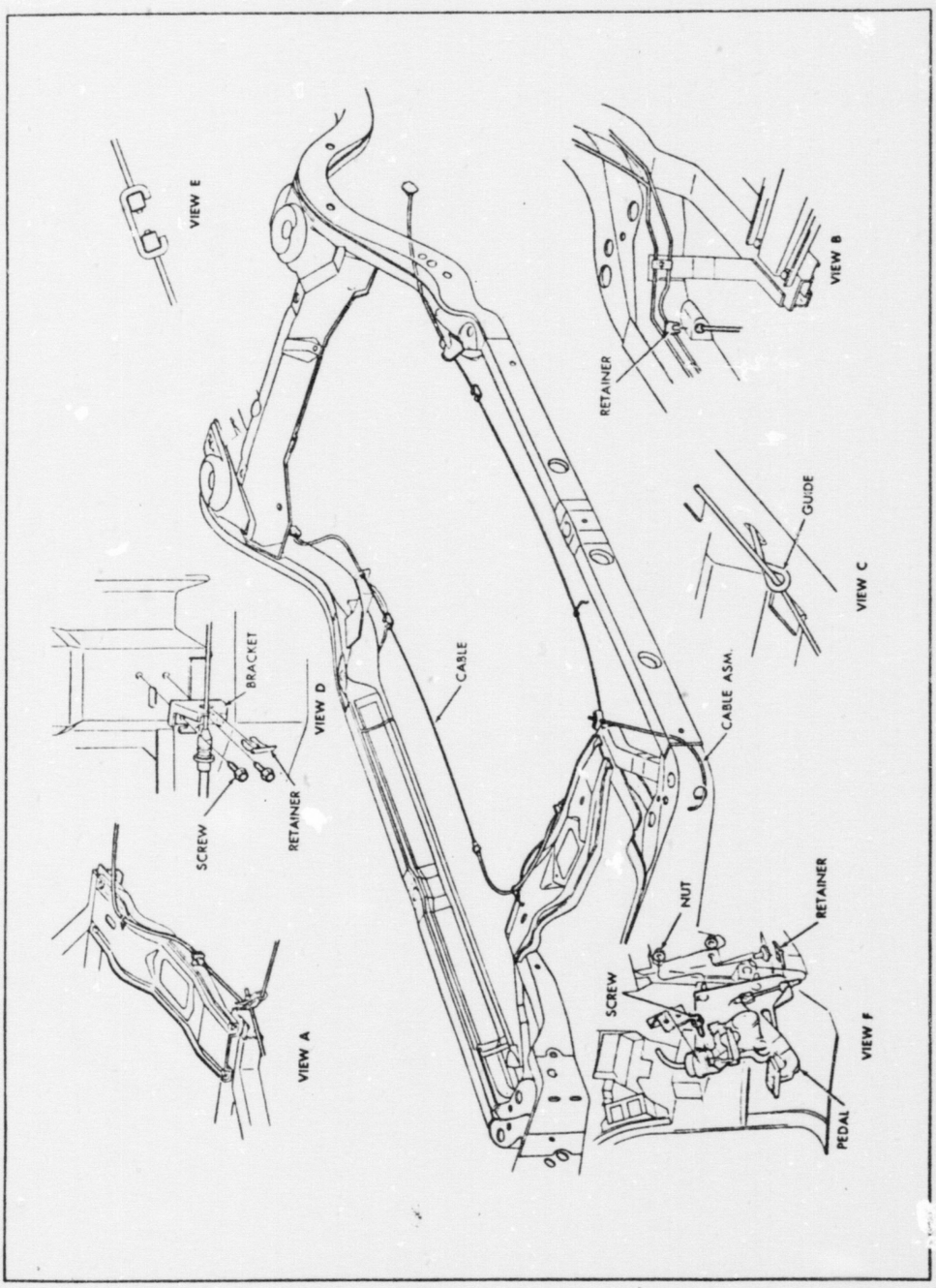



Fig. 5-46 Parking Brake

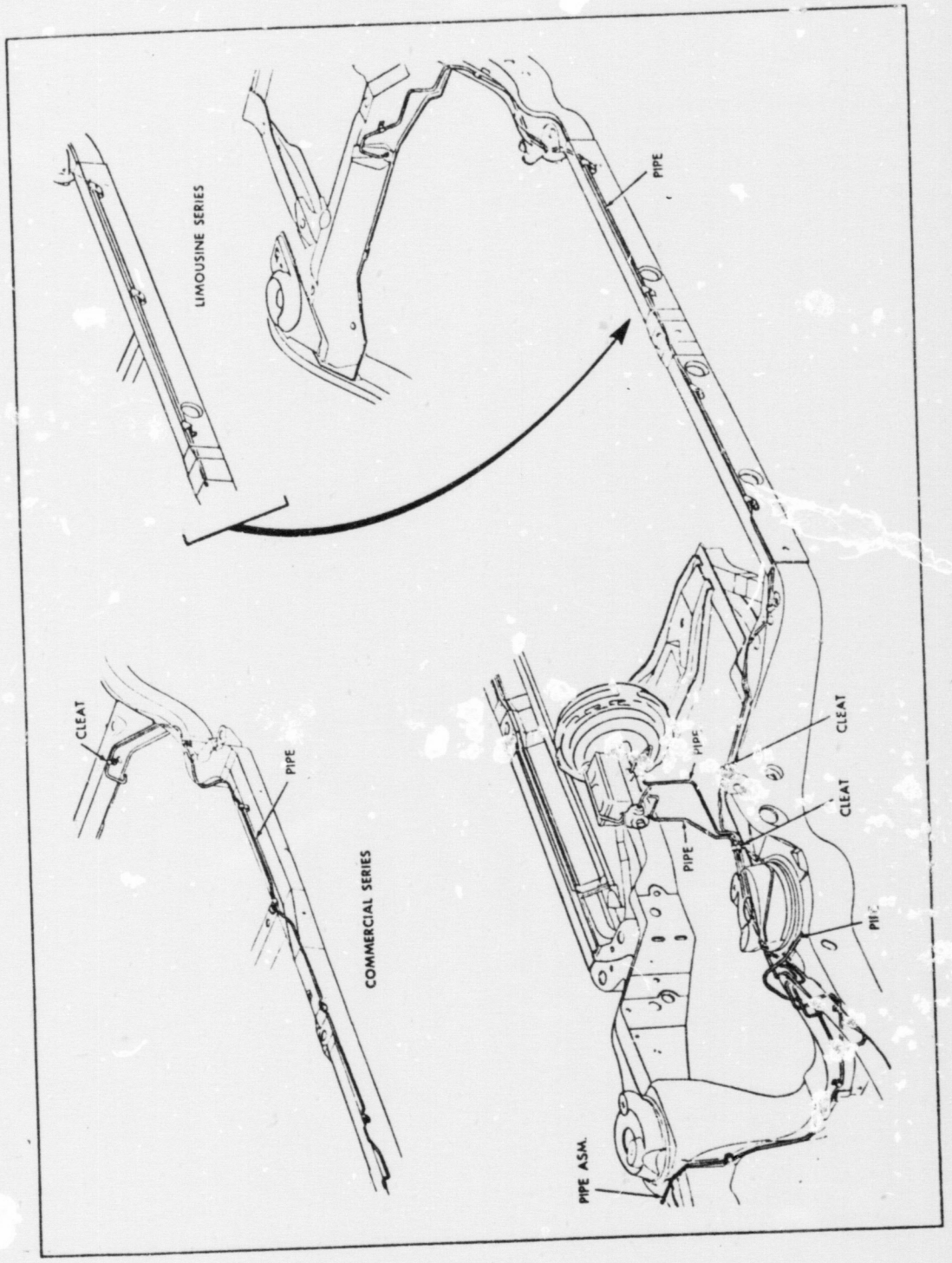



Fig. 5-47 Brake Lines-1



[PX 156, p 5-35]

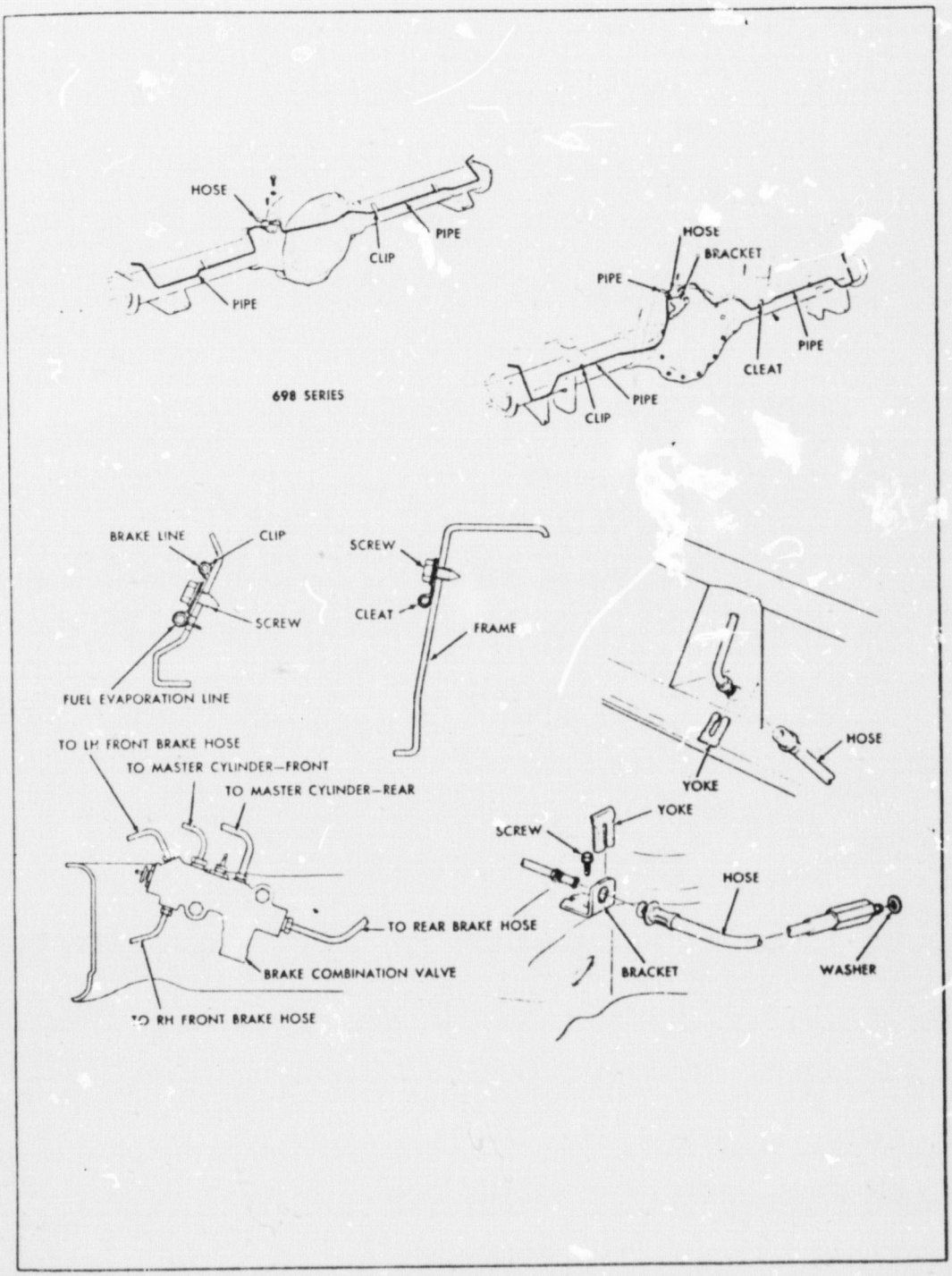



Fig. 5-48 Brake Lines-2

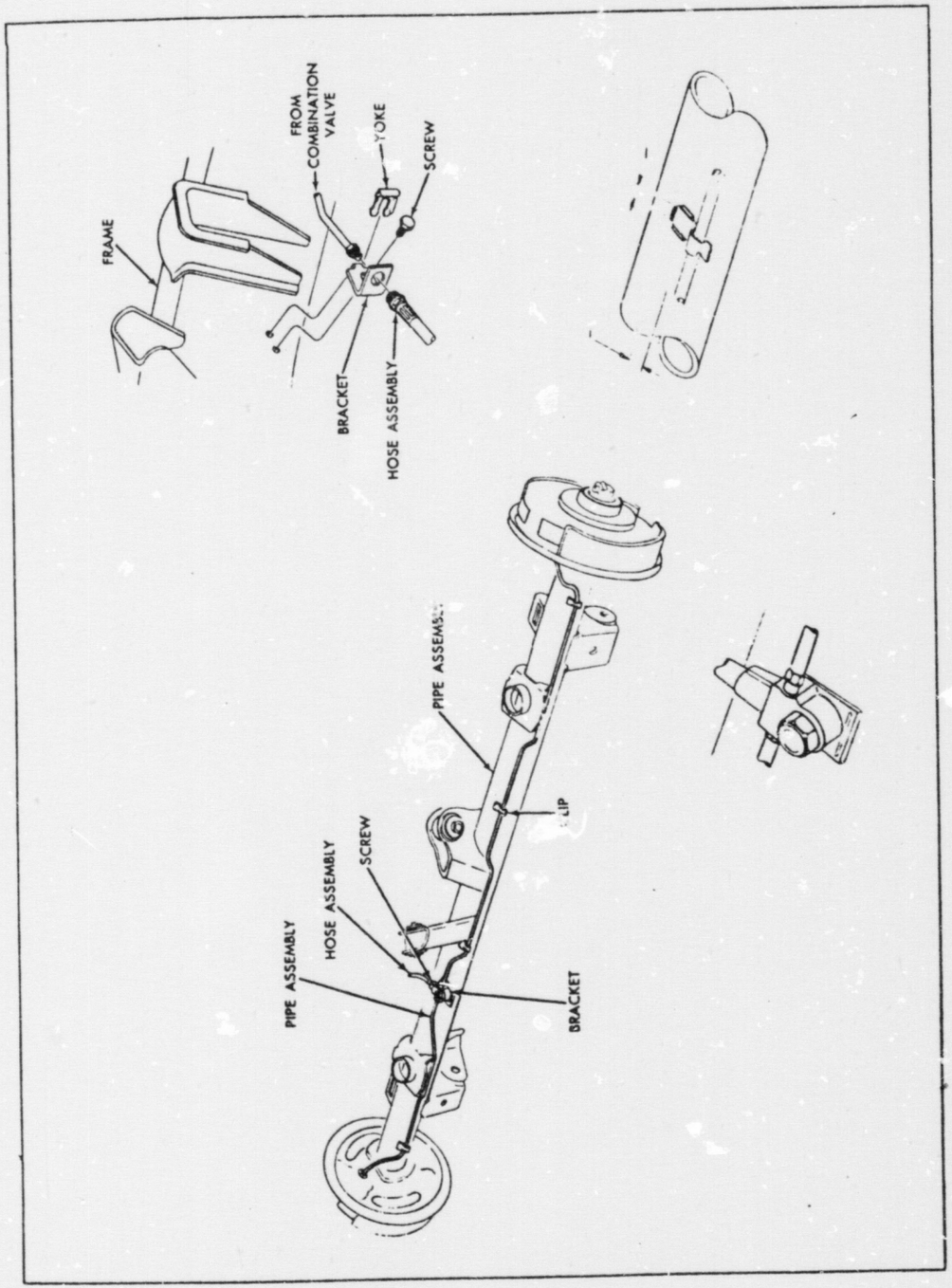



Fig. 5-49 Service Brake Pedal Mounting



[PX 156, p 5-37]

## THEORY OF OPERATION

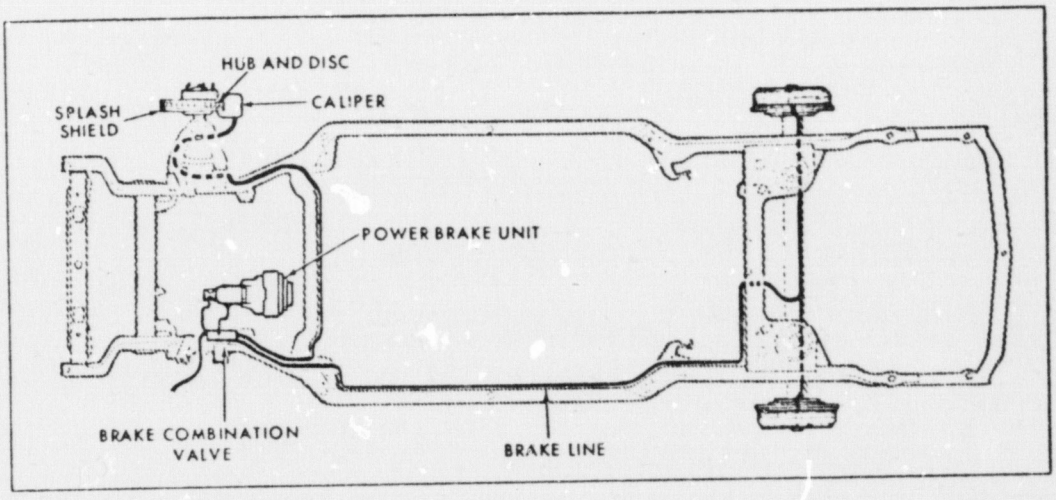



Fig. 5-50 Location of Components-Eldorado

(NOTE: The following information pertains only to the Eldorado, Fig. 5-50.

### Single Piston Sliding Caliper Front Disc Brakes

The single piston sliding caliper front disc brake used on the Eldorado is serviced in the same manner as those installed on other Cadillac cars. The following items are distinctive to the Eldorado.

### Hub and Disc

The Eldorado disc is loose mounted or "floating" as opposed to an integral unit on other cars. The disc and hub are separate components so that disc replacement does not require replacing the hub and bearings. The disc is held in place by lug nuts and may be removed as easily as a brake drum once the caliper is removed. The disc is 11" in diameter on the Eldorado only.

### Brake Combination Valve

The combination valve is mounted on a bracket to the rear of the left side upper shock absorber mounting bracket and is secured to the frame side rail by two tapping screws. The operation of the brake combination valve is the same as all other Cadillac models.

## SERVICE INFORMATION

(NOTE: The service information that follows pertains only to the Eldorado. For service procedures not given, refer to the forward portion of this section, as these procedures are the same as for the other Cadillac models.)

### 30. Disc Assembly Removal and Installation

**a. Removal**

1. Raise car and remove front wheel.
2. Remove two bolts which hold caliper to steering knuckle.

(NOTE: It is not necessary to remove brake hose from caliper when removing disc for service.)

3. Remove cotter pin, loosen joint upper ball nut and slip brake hose collar out of its clip. The slack gained will permit removal of caliper without pulling hose.
4. Slide caliper off disc and support by a hook-shaped wire fastened to upper control arm.

*CAUTION: Do not allow caliper to hang from brake hose.*

5. Mark a wheel stud and a corresponding place on the disc to assist in installation.
6. Remove the disc by sliding it off the hub.

**b. Installation**

1. Inspect hub flange and disc mating surfaces to make sure that they are free of dirt and other foreign material. Clean as required.
2. If reinstalling original disc, align index marks on hub and disc and slide disc over hub pilot diameter, making sure that disc is seated against hub flange.

(NOTE: If disc replacement is necessary, the new disc may be assembled to the hub in any position. It

is not necessary to replace both discs if one is all right.)

3. Position caliper on disc and line up holes in caliper ears with holes in steering knuckle. Make sure brake hose is not twisted, as its natural curvature is essential to maintain proper hose-to-suspension clearance through full movement of suspension and steering parts.

4. Wipe all dirt and corrosion from the caliper mounting bolts. Do not use abrasives, as they will remove protective plating. Lubricate smaller ends of bolts with silicone lubricant.

5. Start either bolt into the inboard ear of the caliper and into the steering knuckle. At this point it is necessary to be sure that the bolt passes under the retaining ear on the inboard shoe to maintain the shoe in position in the caliper, Fig. 5-11.

6. Pass the bolt on through the outboard ear on the caliper until the threads on the bolt can be started into the steering knuckle.

7. Repeat steps 5 and 6 in placing remaining bolt into caliper assembly.

*(See CAUTION page 5-8, prior to NOTE 6 for steps 8, 12, 13.)*

8. Tighten caliper mounting bolts to 30 foot-pounds.

9. Pump brake pedal to seat lining against rotors.

10. Clinch upper ears of outboard shoe by positioning 12" pliers with one jaw on top of upper ear and one jaw in notch on bottom of shoe, opposite upper ear, see Fig. 5-12.

(NOTE: After clinching, there should be no radial clearance between the shoe ears and caliper housing.)

11. If radial clearance exists, repeat clinching procedure.

12. Center brake hose collar in clip and tighten ball joint nut to 60 foot-pounds. Install cotter pin.

13. Install wheels, tighten wheel mounting nuts to 130 foot-pounds and lower car.

14. Allow car weight to be supported on front wheels and inspect front brake hoses for twisted condition. If necessary, correct as described in Note 34b.

15. Before moving the vehicle, pump the brake pedal two or three times to insure firm pedal.

## 31. Relining Rear Drum Brakes (Fig. 5-51)

When brake relining is necessary, it is recommended that the complete brake lining and shoe assemblies be replaced with new assemblies. New lining and shoe assemblies are precision-ground to fit the drum diameter, minimizing the possibility of imperfect braking action due to warped brake shoes or partial contact between linings and drum. This simplifies the complete relining operation and insures a satisfactory job for the customer.

Those Service Departments that have adequate brake shoe relining equipment may obtain linings, drilled and cut to size, from their servicing Parts Warehouses. Brake lining-grinding equipment should incorporate brake shoe holders that locate the shoes accurately in relation to the anchor end, as brake anchors are not adjustable and require accurately ground linings.

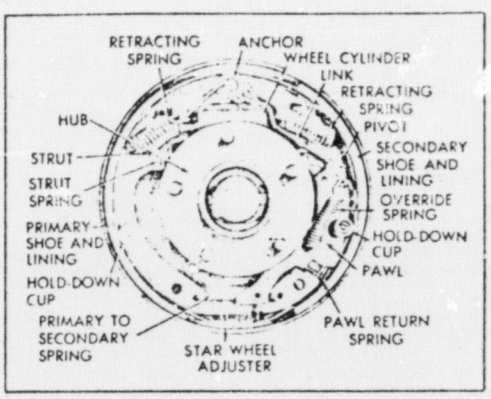



Fig. 5-51 Drum Brake Mechanism-693

1. Release parking brake, raise car, and remove rear wheels and drums. A clip nut on one wheel stud retains the drum to the hub during removal.

*CAUTION: When handling brake drums, be extremely careful not to drop the drum or get brake fluid or grease on friction surface.*

2. Loosen parking brake cable locknut at equalizer.

3. Remove primary brake shoe retracting spring, using Brake Spring Remover and Installer, J-8049.

4. Disconnect link at anchor, using Brake Spring Remover and Installer, J-8049, and remove link, secondary brake shoe retracting spring, and anchor plate.

5. Remove primary brake shoe hold-down cup, spring, washer and pin, secondary brake shoe hold-down cup, spring, pin and sleeve.

6. Remove pivot pawl and override spring as an assembly, and remove pawl return spring.

7. Spread brake shoes and remove parking brake strut rod and spring.

8. Remove parking brake operating lever from secondary brake shoe and remove shoe and lining assemblies from brake backing plate.

9. Remove star wheel adjuster and primary-to-secondary connecting spring from brake shoes.

10. Clean brake backing plate and all brake parts.

*CAUTION: Make certain that hands are clean when handling brake parts. Avoid handling friction surfaces of drums and linings.*

11. Torque nuts that hold backing plate to rear spindle to 30-40 foot-pounds torque.

*(See CAUTION page 5-8 prior to Note 6.)*

12. Lubricate threads and socket of star wheel adjuster and points of contact between brake shoes and other brake parts with special heat resistant lubricant, available from servicing Parts Warehouses. Use sparingly, especially on brake shoe pads.

13. Thread star wheel adjusting screw completely into pivot nut to permit installation of brake drum over replacement brake shoes.

14. Install star wheel adjuster and primary-to-secondary connecting spring on replacement brake shoes.

*CAUTION: Star wheel adjusters with three wide groove on O.D. of pivot nut (left hand thread) are installed on right side of car, with those with three narrow groove (right hand thread) on O.D. of pivot nut are installed on left side of car.*

15. Install parking brake operating lever on secondary brake shoe and position shoe and lining assemblies to brake backing plate.

16. Install parking brake strut rod and spring on brake shoes.

(NOTE: Spring is positioned against primary brake shoe web).

17. Engage brake shoes with wheel cylinder connecting links and install primary brake shoe hold-down pin, washer, spring (green) and cup.

18. Install anchor plate and position pivot, pawl and override spring as an assembly to secondary brake shoe.

19. Install link and pawl return spring and secure all parts to secondary brake shoe by installing hold-down sleeve.

20. Install secondary brake shoe hold-down pin, spring (maroon) and cup.

21. Install primary brake shoe retracting spring (grey) using Brake Spring Remover and Installer, J-8049.

22. Install secondary brake shoe retracting spring (blue) using Brake Spring Remover and Installer, J-8049.

23. Install rear brake drums and clip nut retaining drum to hub.

24. Perform manual service brake adjustment as described in Note 7.

25. Install rear wheels and lower car. Tighten wheel mounting nuts to 130 foot-pounds.

26. Adjust parking brake as described in Note 8.

## 32. Parking Brake (Fig. 5-52)

### a. Front Cable

The procedure for removing and installing the front parking brake cable is described in Note 22a and 22b respectively.

### b. Removal—Center Cable

1. Release parking brake.
2. Remove equalizer nut and washer from cable stud and remove equalizer.
3. Remove cable from wire guide at center of torsion bar support.
4. Remove cable from hook at right side of underbody.
5. Remove cable from right and left connectors to rear cables.
6. Thread cable out of torsion bar support and through underbody bracket. Remove cable.

### c. Installation—Center Cable

1. Thread cable through underbody bracket and torsion bar support.
2. Install cable in right and left connectors.
3. Install cable in hook at right side of underbody.
4. Install cable in wire guide at center of torsion bar support.
5. Install equalizer on cable stud and secure with washer and nut.
6. Check operation of parking brake and adjust as described in Note 8.

### d. Removal—Rear Cable

1. Release parking brake.
2. Raise rear of car and position on jack stands.
3. Remove rear wheels and drums.
4. Loosen equalizer nut and washer.
5. Remove cable from connector.
6. Remove clips retaining parking brake cable to lower control arm brackets on right and left sides.
7. Remove cable ends from parking brake operating levers, and remove cable ends from backing plates.

### e. Installation—Rear Cable

1. Install cable ends through backing plates and connect to parking brake operating levers.
2. Install pawl lever and pawl spring.

*CAUTION: Pull on cable and check operation of cable and brake mechanisms.*

arm brackets on right and left sides of car, and secure with clip.

4. Install cable in connector.
5. Tighten equalizer nut and washer.
6. Install rear drums and wheels. Tighten wheel mounting nuts to 130 foot-pounds.
7. Adjust parking brake as described in Note 8.

## 33. Brake Combination Valve

### a. Removal

1. Raise hood.
2. Disconnect wiring connector from valve.
3. Disconnect three brake pipes from top and one from front of valve and remaining brake pipe from bottom of valve.
4. Remove two bolts securing valve to frame bracket and remove valve.

### b. Installation

1. Position valve to frame bracket and secure with two bolts.
2. Install brake pipe to bottom of valve and one brake pipe to front of valve and three on top.
3. Connect wiring connector to valve.

(NOTE: When replacing a combination valve, rear brake bleeding can be accomplished by allowing brake fluid to flow from the rear brake pipe nut at the valve. Back off this nut one turn and catch fluid flow in a cloth or a container until air is elinunated.

The front brakes should be bled at the calipers in the usual manner. Then, before driving car, be sure a firm pedal is obtained.)

4. Bleed brakes as described in Note 6.
5. Close hood.

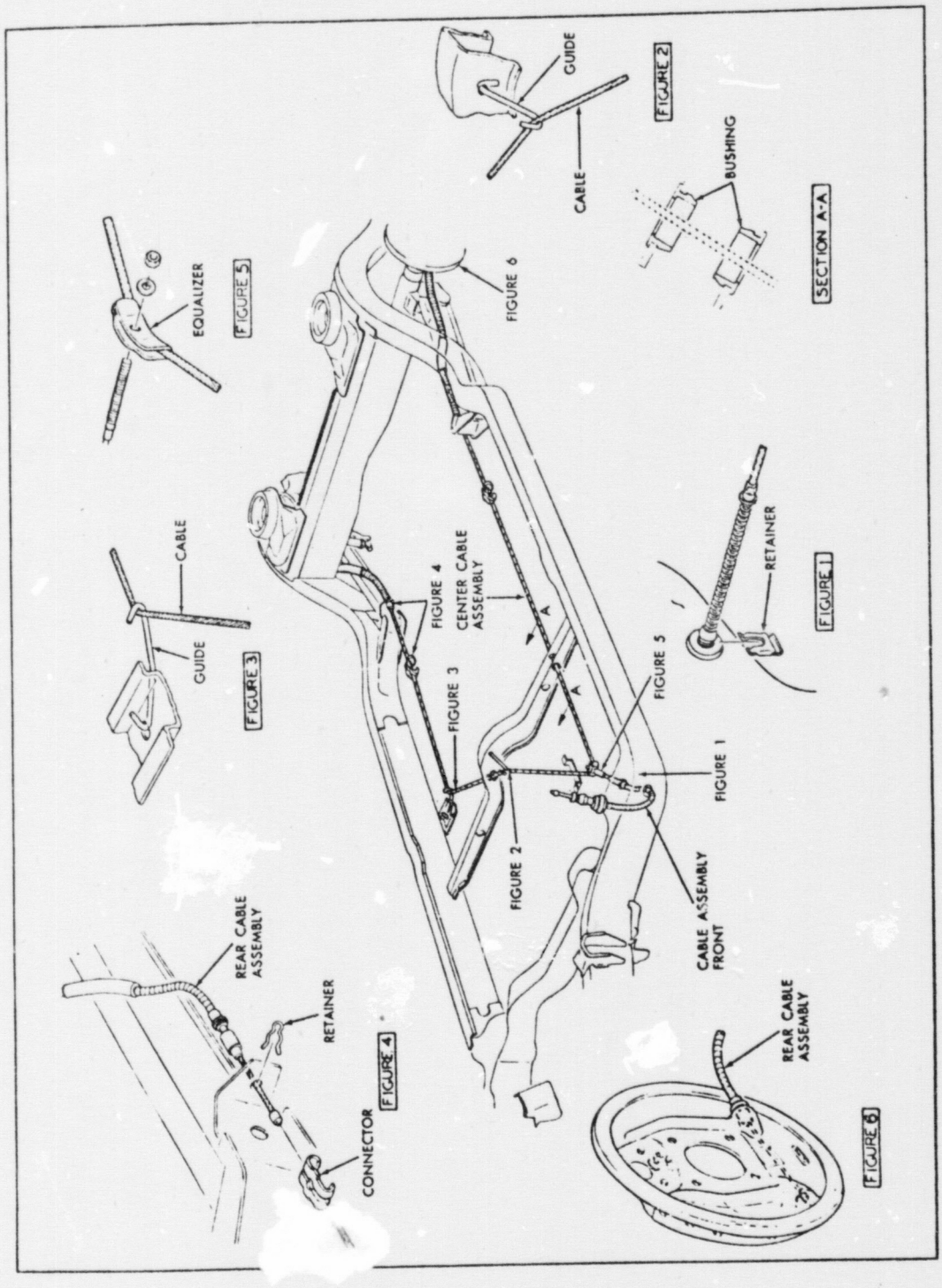



Fig. 5-52 Eldorado Parking Brake-1

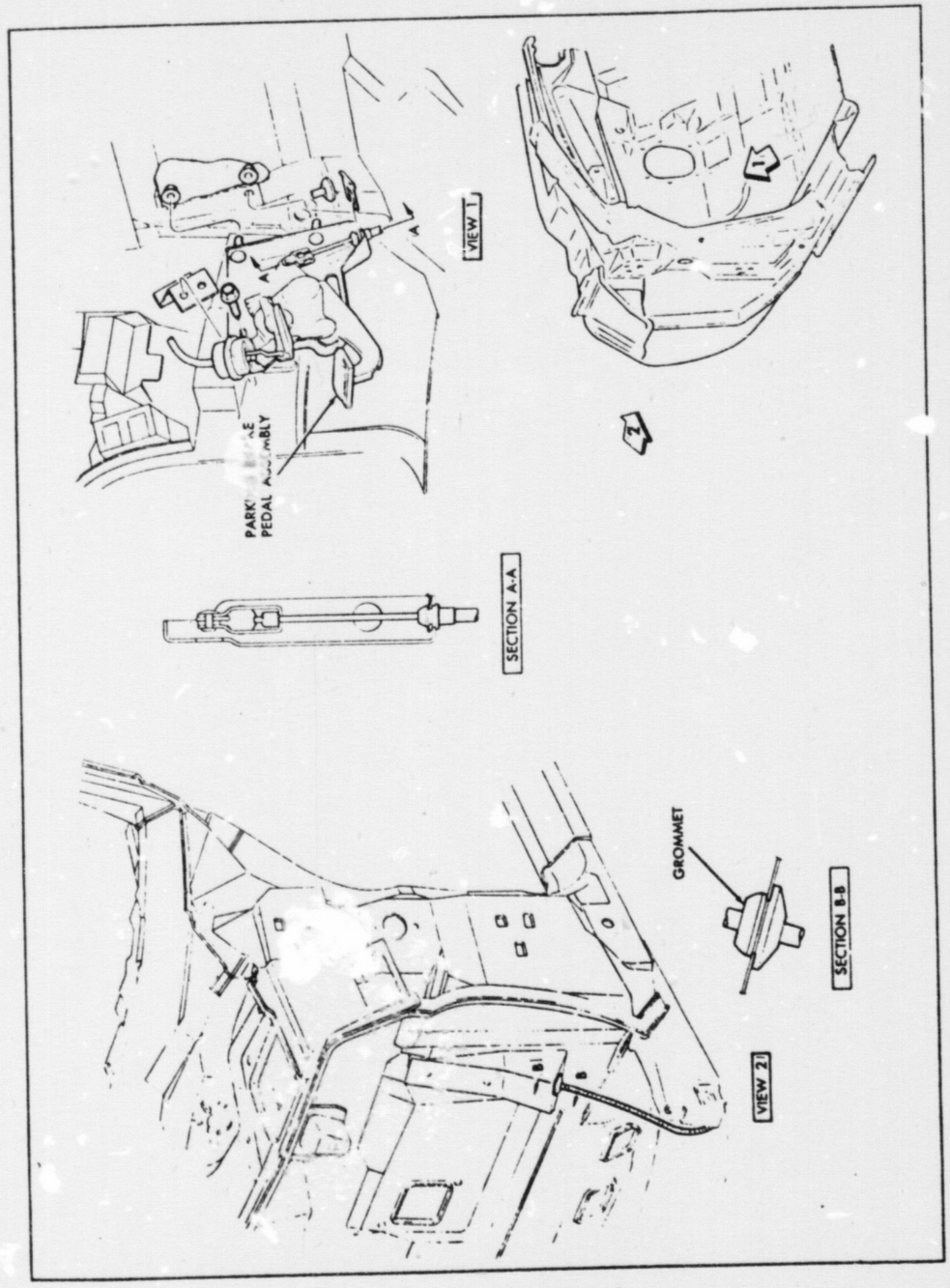



Fig. 5-53 Eldorado Parking Brake-2

## 34. Servicing Hydraulic Brake Hoses and Piping (Fig. 5-53)

Hydraulic pressure is transferred to the wheel cylinders through steel brake piping, flexible hoses, and a brake combination valve.

The steel brake lines and flexible hoses should be inspected every spring and fall for damage that may occur from various road hazards.

While the flexible hoses and steel piping require no periodic servicing, it may be necessary to replace damaged hoses or piping in the following manner:

### a. Removal—(Front Wheels)

1. Disconnect steel brake line from hose at frame bracket by turning steel tube fitting out of hose fitting. Cap fitting to prevent dirt from entering brake line.

2. Remove U-shaped retainer from hose at frame support bracket and remove hose from bracket.

3. Remove cotter pin and nut securing upper ball joint to knuckle and remove clip securing brake hose to ball joint stud.

4. If right front hose is being replaced, remove clip retaining hose to frame.

5. Turn hose out of inlet fitting of caliper and remove and discard copper gasket. If hose is to be reused, cap end fittings to prevent dirt from entering hose.

### b. Installation—(Front Wheels)

1. Install new copper gasket on caliper end of hose (male end).

2. Tighten hose in caliper inlet to 30 foot-pounds maximum torque.

*CAUTION: Never tighten hose in wheel cylinder inlet with hose attached at frame end, as this will twist the hose.*

3. Install brake hose clip on upper ball joint stud and install ball joint retaining nut on stud. Tighten ball joint nut finger tight.

4. With suspension in normal position (front wheels straight ahead and front suspension at normal standing height) pass female end of hose through frame support bracket, allowing hose to seek its own position. Insert hex of hose fitting into the slot hole in support bracket in the position that will result in least twisting of hose.

(NOTE: Do not twist hose any more than necessary during this operation as its natural curvature is essential to maintain proper hose-to-suspension clearance through full movement of suspension, steering and driving parts.)

5. Install U-shaped retainer to secure hose to frame support bracket.

6. If right front hose is being replaced, install clip securing hose to frame.

7. Inspect by turning wheels from stop-to-stop while observing hose position. Be sure that hose does not touch any other part at any time during steering travel. If contact does occur, remove hose retainer, and if necessary loosen upper ball joint nut, and reposition hose as necessary. Replace clip, tighten ball joint nut finger tight, and reinspect.

8. When hose is properly positioned, torque ball joint nut to 60 foot-pounds minimum.

*(See CAUTION page 5-8 prior to Note 6.)*

(NOTE: If cotter pin cannot be installed, tighten nut to next hole and install cotter pin.)

*CAUTION: When installing cotter pin, make sure ends of pin are pinched right against flat of nut. DO NOT let end of cotter pin extend down toward outer drive axle seal.*

9. Install steel brake line fitting into brake hose at frame support bracket and tighten fitting to 20 foot-pounds maximum torque.

10. Bleed brakes as described in Note 6.

### c. Removal—Hydraulic Brake Piping (Rear Wheels)

1. Disconnect steel brake piping at rear wheel cylinder fitting. Cap fitting to prevent dirt from entering wheel cylinder.

2. Disconnect brake piping at brake line junction fitting on rear axle.

3. If left brake pipe is being removed, bend clip open and remove pipe.

4. If right brake piping is being removed, bend clips open and remove piping.

### d. Installation—Hydraulic Brake Piping (Rear Wheels)

1. Position brake piping to rear axle and hand start tube nuts into wheel cylinder and junction block.

a. If right brake piping is being installed, bend clips over pipe, retaining piping to rear axle.

b. If left brake piping is being installed, bend clip retaining piping to rear axle.

2. Tighten piping to brake line junction fitting on rear axle, tighten to 20 foot-pounds maximum torque.

3. Tighten brake piping to rear wheel cylinder fitting, tighten to 20 foot-pounds maximum torque.

4. Bleed all brakes as described in Note 6.

### e. Removal—Hydraulic Brake Hose (Rear Wheels)

1. Disconnect steel brake pipe from hose. Cap pipe.

2. Remove retainer securing forward end of brake hose to frame.

3. Remove bolt from junction block on axle.

4. Disconnect rear axle piping from junction block. Cap pipes.

### f. Installation—Hydraulic Brake Hose (Rear Wheels)

1. Connect rear axle piping to junction block. Tighten fittings to 20 foot-pounds maximum torque.

2. Bolt junction block to axle.

3. Pass female end of hose through frame allowing hose to seek its own position.

4. Install retainer to secure hose to frame.

5. Place steel tube connector in hose fitting and tighten to 20 foot-pounds maximum torque.

*CAUTION: Do not allow hose to twist out of its normal position.*

6. Bleed all brakes as described in Note 6.

## TORQUE SPECIFICATIONS—ELDORADO ONLY

| Material Number | Application | Size | Foot-Pounds |
|---|---|---|---|
| 280M | Bearing Retainer/Splash Shield to Knuckle | 3/8-16 | 30 |
| 286M | *Brake Backing Plate to Rear Axle Housing | 3/8-24 | 35 |
| | Upper Ball Joint Nut | | 60 |
| | For other Torque Specifications Refer to Page 5-31 | | |
| (NOTE: Refer to back of Manual, Page 16-1, for bolt and nut markings and steel classifications.) | | | |

**CAUTION: This fastener is an important attachi part in that it could affect the performance of vital components and systems, and/or could result in major repair expense. It must be replaced with one of the same part number or with an equivalent part if replacement becomes necessary. Do not use a replacement part of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of this part.*

## SPECIFICATIONS

| Item | Eldorado Series Cars |
|---|---|
| Swept Braking Area (in square inches) | |
| Front | 224 |
| Rear | 138 |
| Lining Area (in square inches) | |
| Front | 41.76 |
| Rear | 84 |
| Wheel Cylinder Bore | |
| Front | 2-15/16" |
| Rear | 15/16" |
| Drums (inside diameter) | 11.00" |
| Remachined Drum Diameter (maximum) | 11.06" |
| Worn Drum Diameter (maximum) | 11.09" |
| Variations of Inside Drum Diameter (maximum) | .002" |
| Run-Out of Inside Drum Diameter | .005" |
| Lateral Run-Out of Disc on Hub (Maximum) | .008" |
| Flatness and Parallelism Between Frictional Surfa s of Disc | .0005" |
| Minimum Disc Thickness | 1.190" |
| Lining Size (length, width, thickness in inches) | |
| Front | Inner Shoe 5.4 x 1.93 x .43<br>Outer Shoe 5.4 x 1.93 x .41 |
| Rear | |
| Primary | 9.00 x 2.00 x .20 |
| Secondary | 12.00 x 2.00 x .29 |
| Lining to Shoe Attachment Method | Rivets |
| Brake Combination Valve | |
| Front Brake Cut-in Pressure | 130 psi |
| Front Brake Blend Pressure | 650 psi |
| Rear Brake Proportioning Pressure Except with Track Master | 41% above 350 psi |
| Rear Brake Proportioning Pressure with Track Master | 41% above 470 psi |
| Failure Warning Differential Pressure | 100-300 psi |

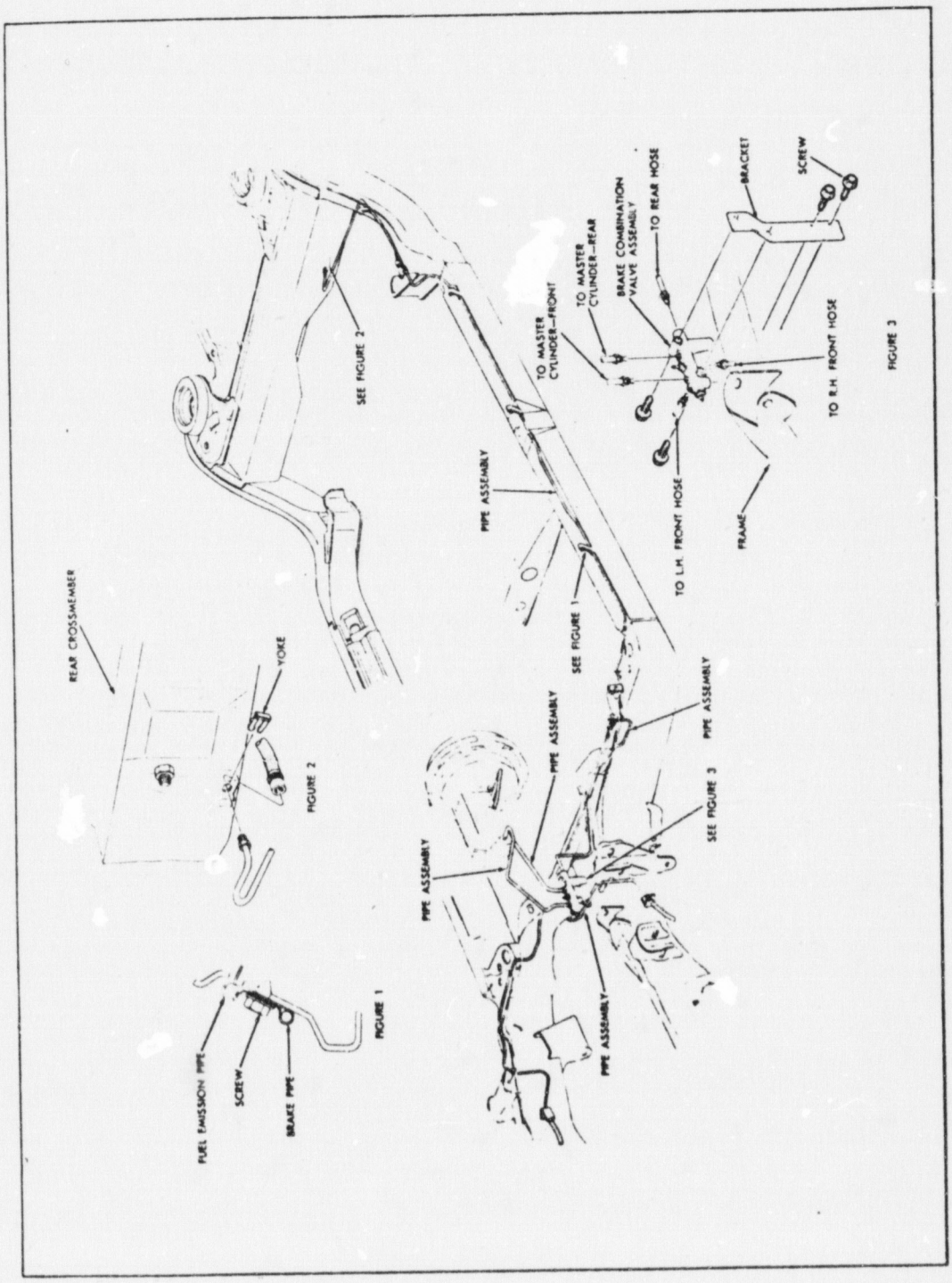



Fig. 5-54 Eldorado Brake Lines-1

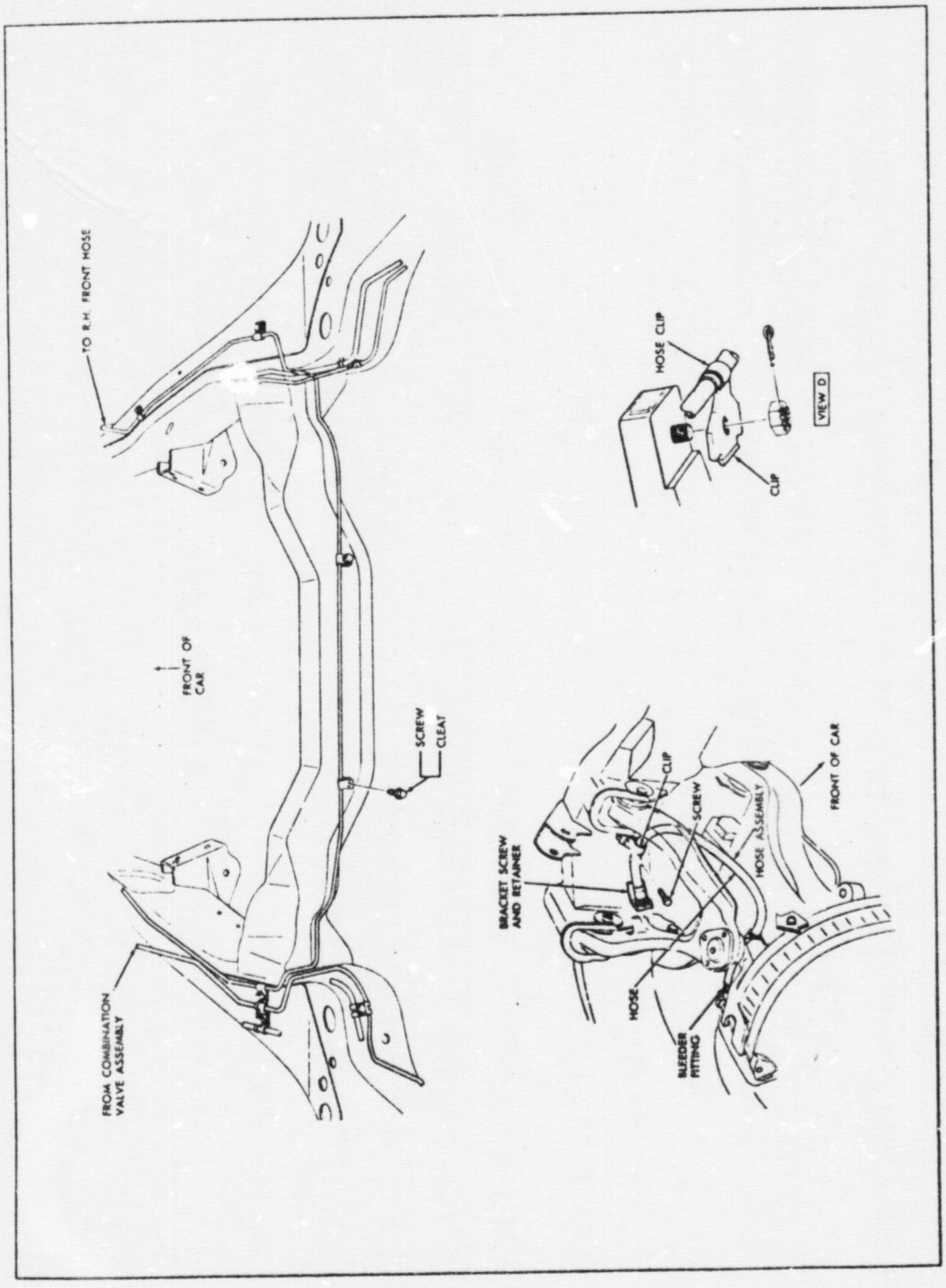



Fig. 5-55 Eldorado Brake Lines-2

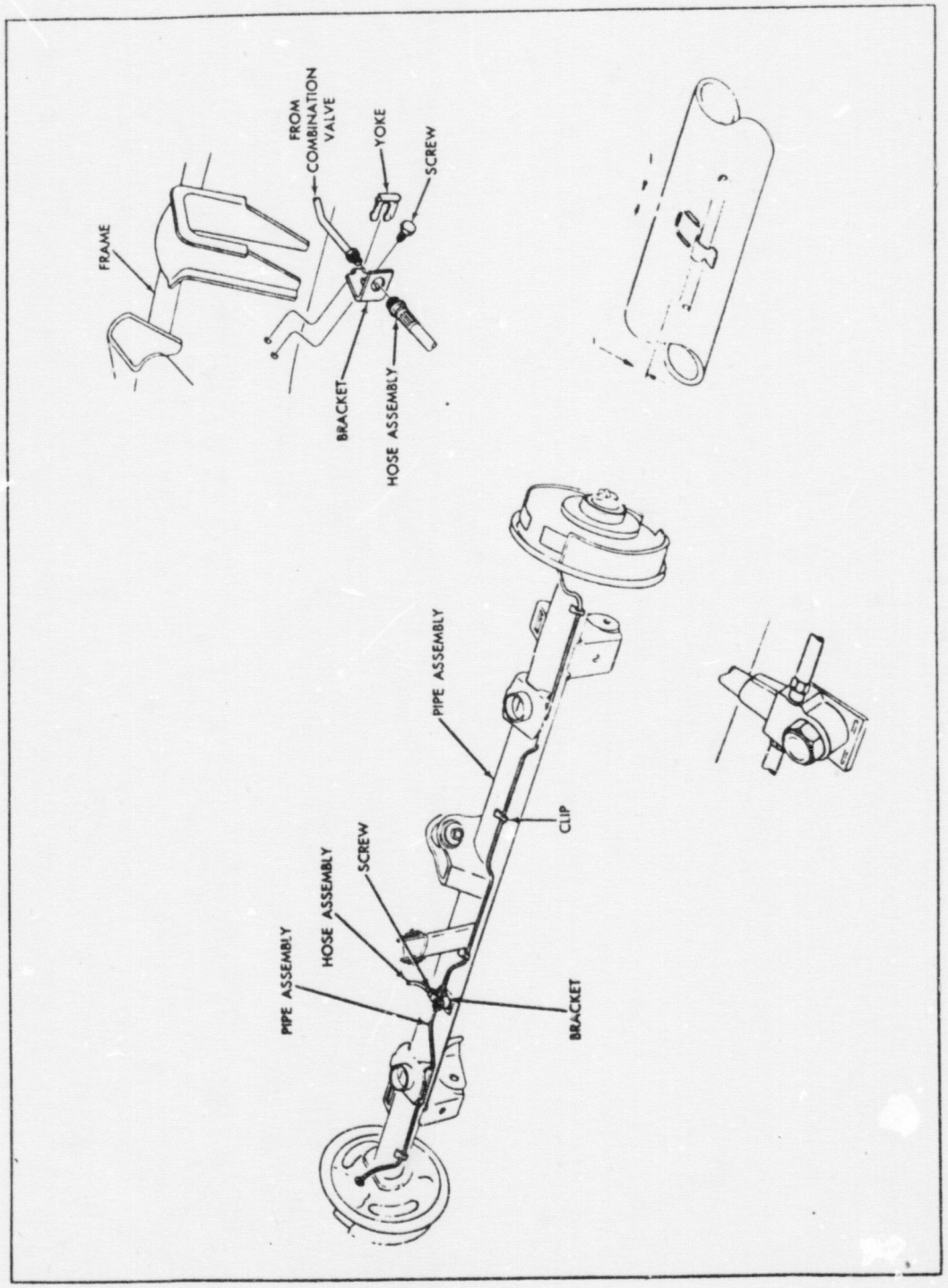



Fig. 5-56 Eldorado Brake Lines-3

# THEORY OF OPERATION

## Purpose of System

Wheel or brake lock-up occurs when the brake is applied so tightly that the wheel is held from turning and skids on the road surface. Since a tire will skid about as easily in one direction as another, a car with locked rear wheels may yaw or swerve, sending the rear end out of control. In severe cases this yaw may result in "spin-out".

Skidding may also increase the distance in which the car may be stopped as friction developed between tire and road surface may be less when sliding than when rolling, especially on a wet surface.

To reduce these undesirable braking characteristics, the Track Master System is available as optional equipment. The primary purposes of the system during a panic stop or other hard application of brakes are: (1) maintain lateral stability of the car; (2) provide near maximum controlled braking effort to decrease stopping distance, on most road surfaces; (3) prevent flat spots on tires.

### Controlling Rear Wheel Lock

All of these objectives are obtained by keeping the rear wheels rolling, with the brakes applied as tightly as possible, without actually locking the rear wheels. In practice, improvement in lateral stability is significant under most driving conditions, while decrease in stopping distance is most effective on wet pavements.

Friction between tire and road will vary widely according to type of tire and its tread condition as well as type of road and its surface condition. These variables make it impossible to predetermine the correct amount of friction and hydraulic pressure to stop without locking the rear wheels.

Instead, this friction must be established automatically in each instance of brake application at the maximum possible, while still allowing the rear wheels to turn. This determination is made by the system sensing when the wheels are beginning to lock.

### Basic Operation

Most car stops are at low rates of deceleration, with only a moderate application of force to the brakes, and the Track Master System is passive. However, the system is energized whenever the ignition is on, and it stands ready to function whenever a rear wheel is about to lock — whether as a result of an emergency stop with good tires on dry concrete or just a slow stop with bald tires on a wet or icy road.

The Track Master System is composed of the following major components: Cadillac has a speed sensor at the transmission while the Eldorado has speed sensors at each rear wheel; controller under instrument panel; and modulator on cowl in engine compartment.

Skid control starts with a speed indication taken from a magnetic pick-up device known as the sensor.

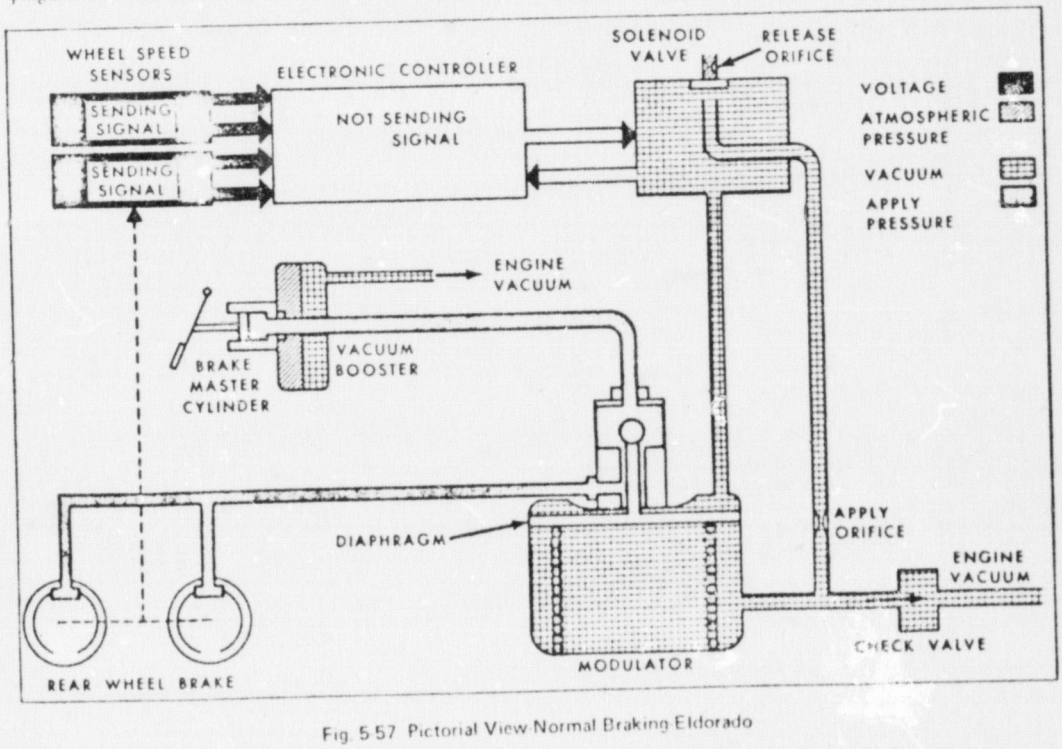



Fig. 5-57 Pictorial View-Normal Braking-Eldorado

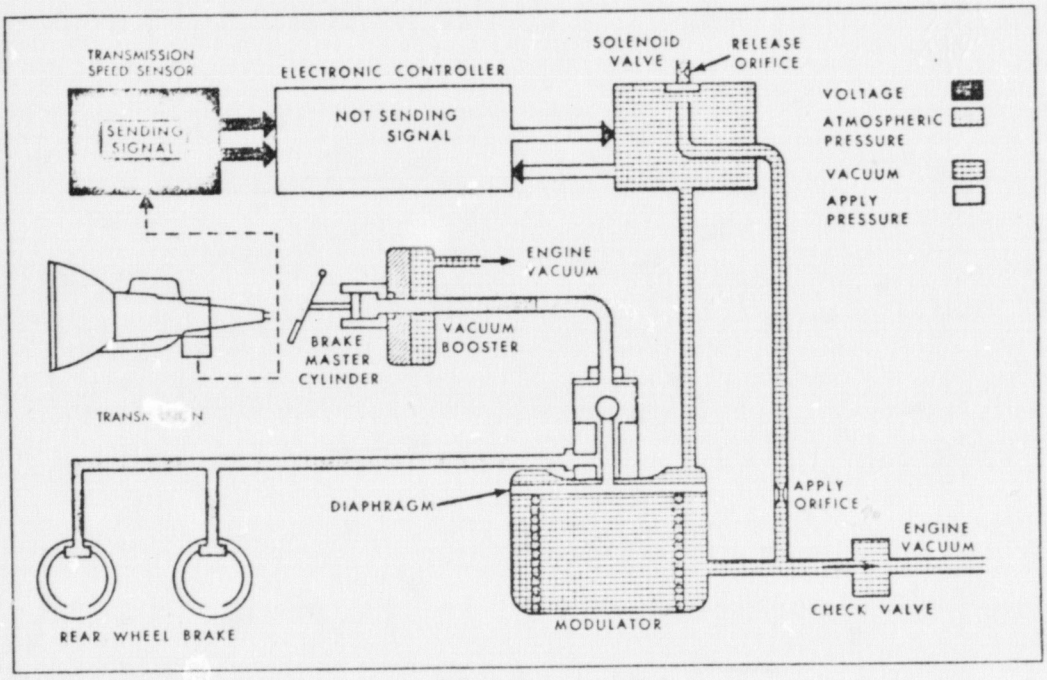



Fig. 5-58 Pictorial View-Normal Braking-Exc. Eld.

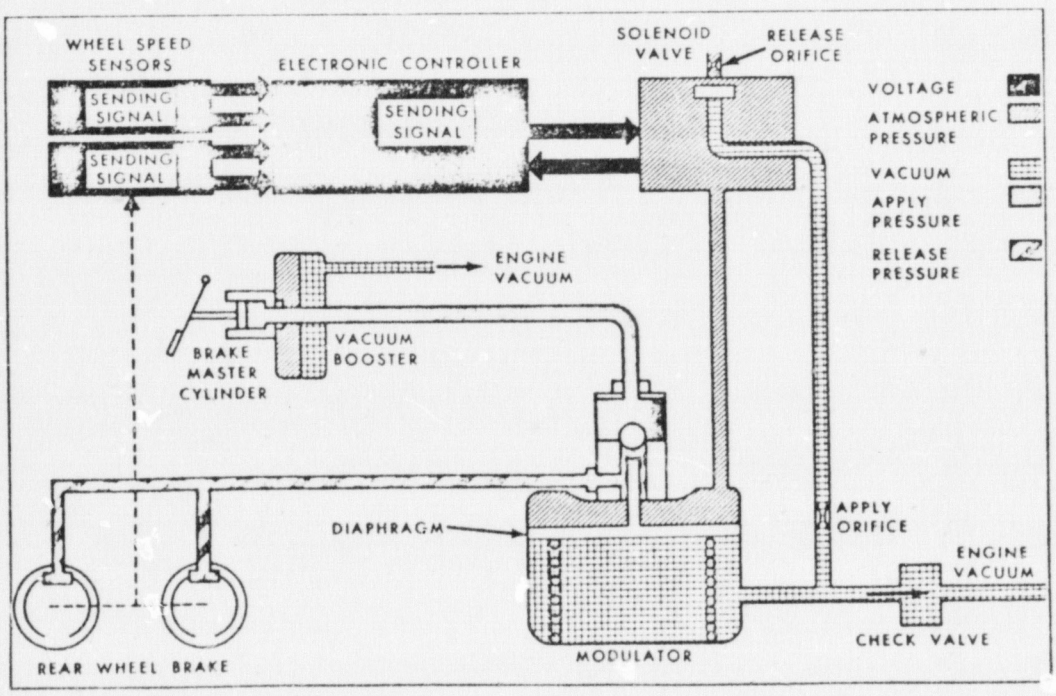



Fig. 5-59 Pictorial View-Release Mode-Eldorado

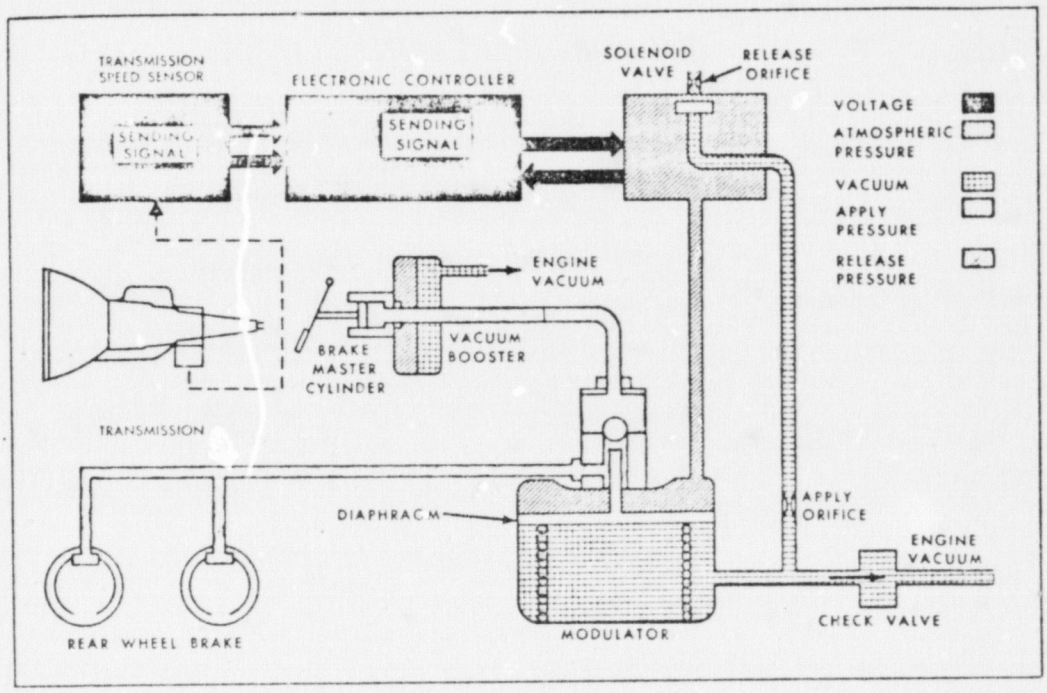



Fig. 5-60 Pictorial View-Release Mode-Exc. Eldorado

The sensor produces an electrical frequency that is proportional to wheel speed. This frequency is monitored by the controller.

When a wheel is not locking during brake application, the wheel will gradually decelerate. However, when a wheel has started to lock, it will decelerate abruptly at a rate much faster than the car's deceleration.

When the controller determines that the frequency changes too rapidly and the car is thereby approaching a skid condition, the controller sends an electrical signal to the modulator solenoid.

The modulator seals hydraulic pressure from the brake master cylinder and then increases the volume from the modulator to the rear wheel cylinders. This increased volume results in decreased hydraulic pressure and partial brake release.

With the rear brakes partially released, the wheels accelerate and, as car speed is approached, the controller senses the condition and de-energizes the modulator.

This action positions the modulator to increase brake pressure to the rear wheel cylinders until a locking condition is again sensed. The entire cycle of partial brake release and re-application occurs in about 1/3 of a second. During a stop where brake pressure is sufficient to cause lock-up, the cycling will continue until the car is slowed to approximately five miles per hour or until the brakes are released by the driver.

Figures 5-57, 5-58, 5-59 and 5-60 are pictorial diagrams of the system in the normal braking and released mode, respectively.

## Control Circuits

Figure 5-61 and 5-62 illustrate the total Track Master System control circuits.

### a. Hydraulic Control Circuit

In addition to the normal brake system components (dual master cylinder, brake combination valve, front wheel cylinders, rear wheel cylinders, connecting brake lines), the hydraulic control circuit also includes the hydraulic check valve. This valve, which is an integral part of the modulator assembly, is connected between the brake combination valve and rear brake wheel cylinders.

### b. Vacuum Control Circuit

This vacuum control circuit includes the vacuum hose connection from the engine manifold, vacuum check valve, valve section of the solenoid valve, and actuator section of the modulator assembly. The vacuum control circuit provides the power necessary to operate the modulator.

### c. Electrical Control Circuit

This electrical control circuit includes the controller, solenoid section of the solenoid valve, speed sensor and modulator travel switch. Electrical power is supplied to the Track Master System when the ignition switch is turned to all positions except "OFF" and "Accessory"

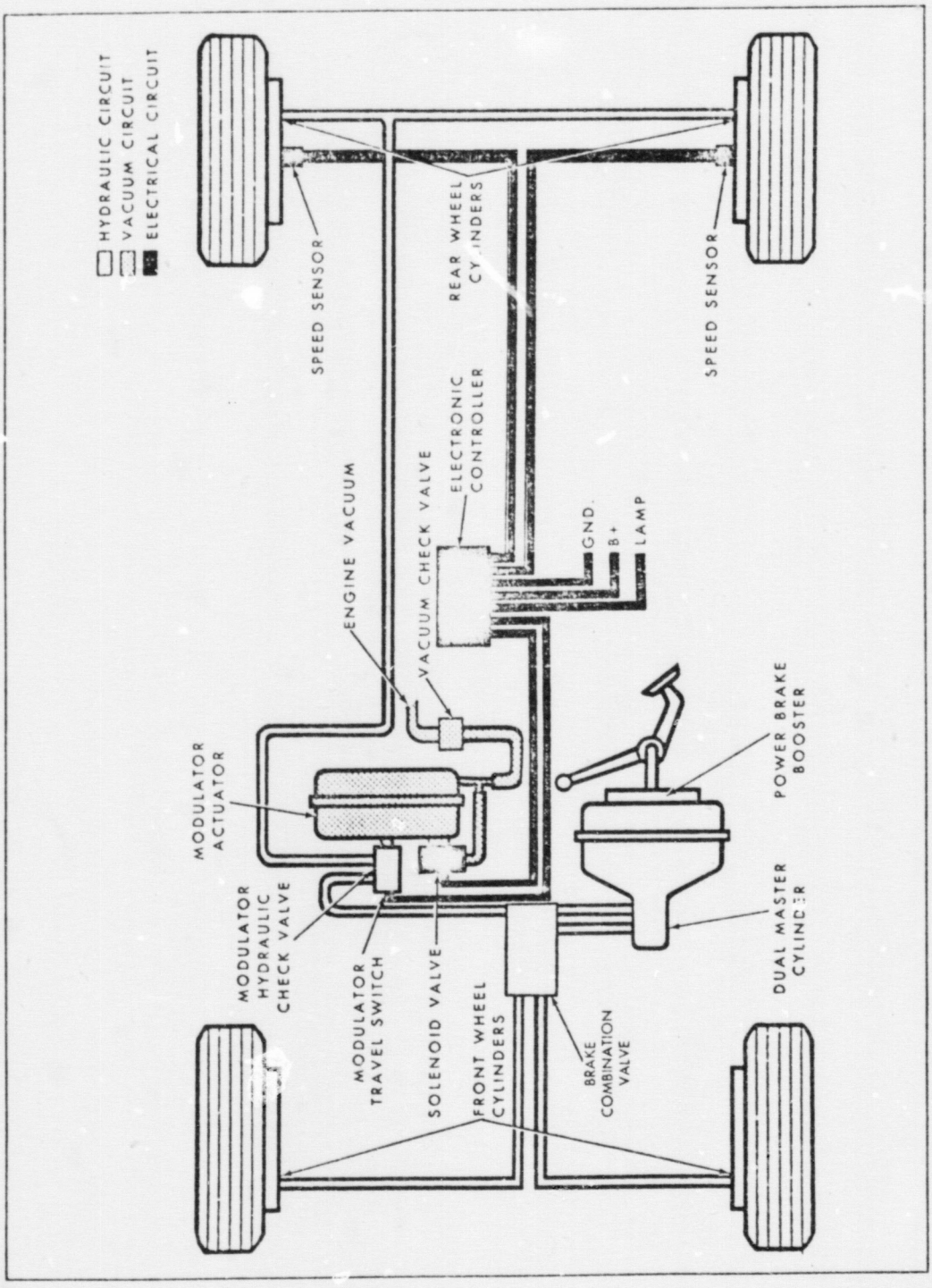



Fig. 5-61 Control Circuits-Eldorado

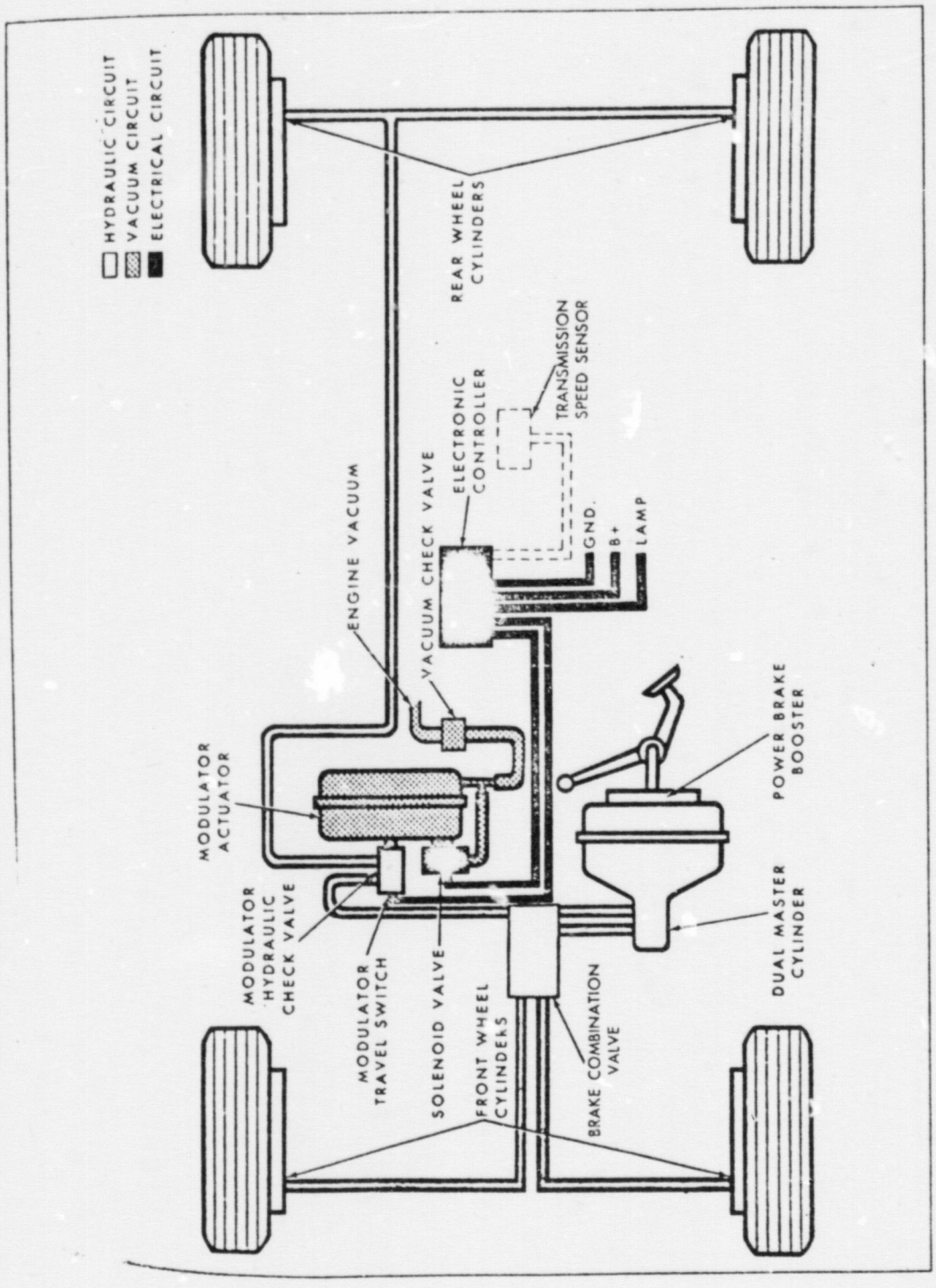



Fig 5-62 Control Circuits-Exc. Eldorado



[PX 156, p 5-52]

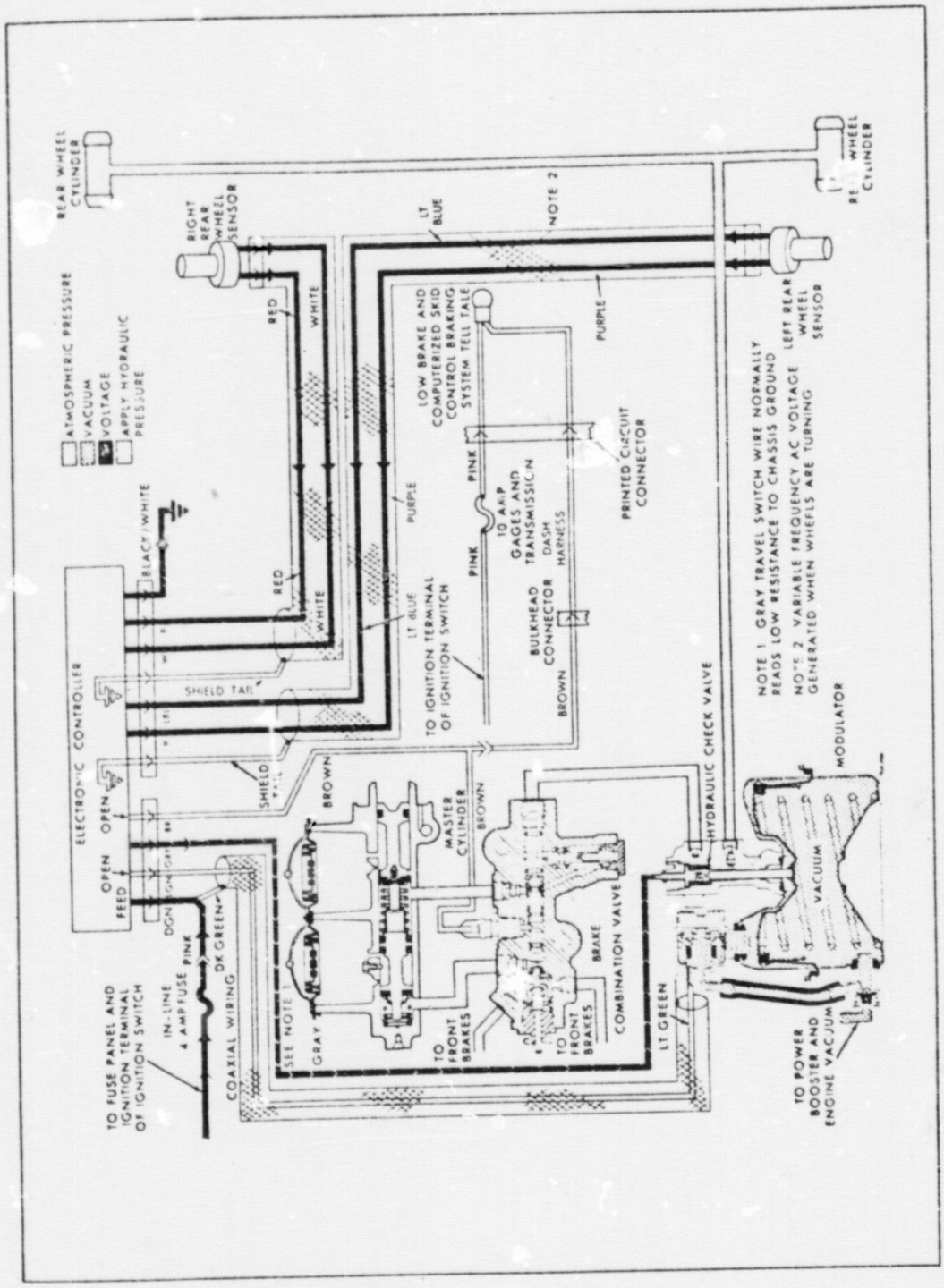



Fig. 5-63 Operation-Normal Braking-Eldorado

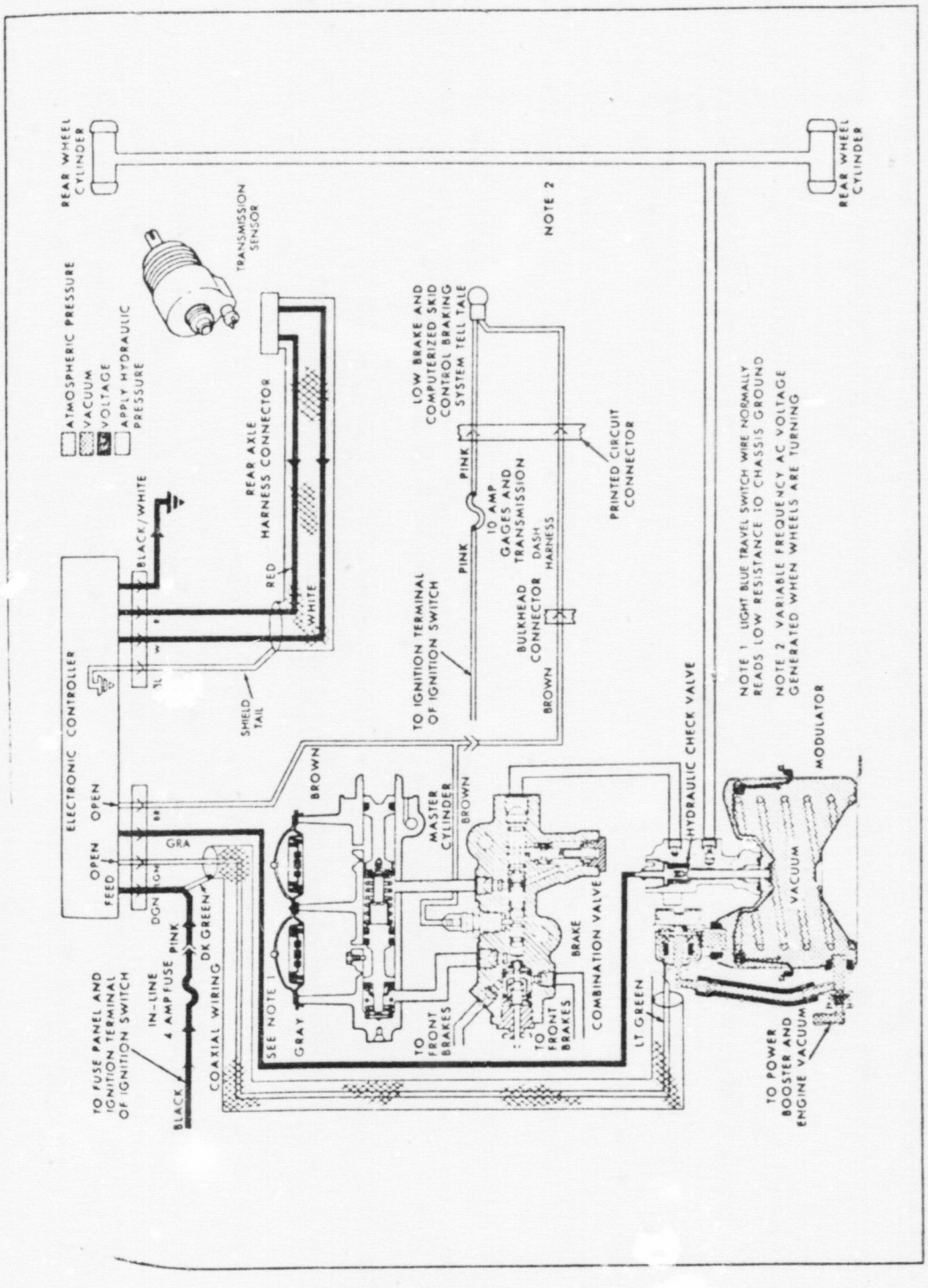



Fig. 5-64 Operation-Normal Braking-Exc. Eldorado

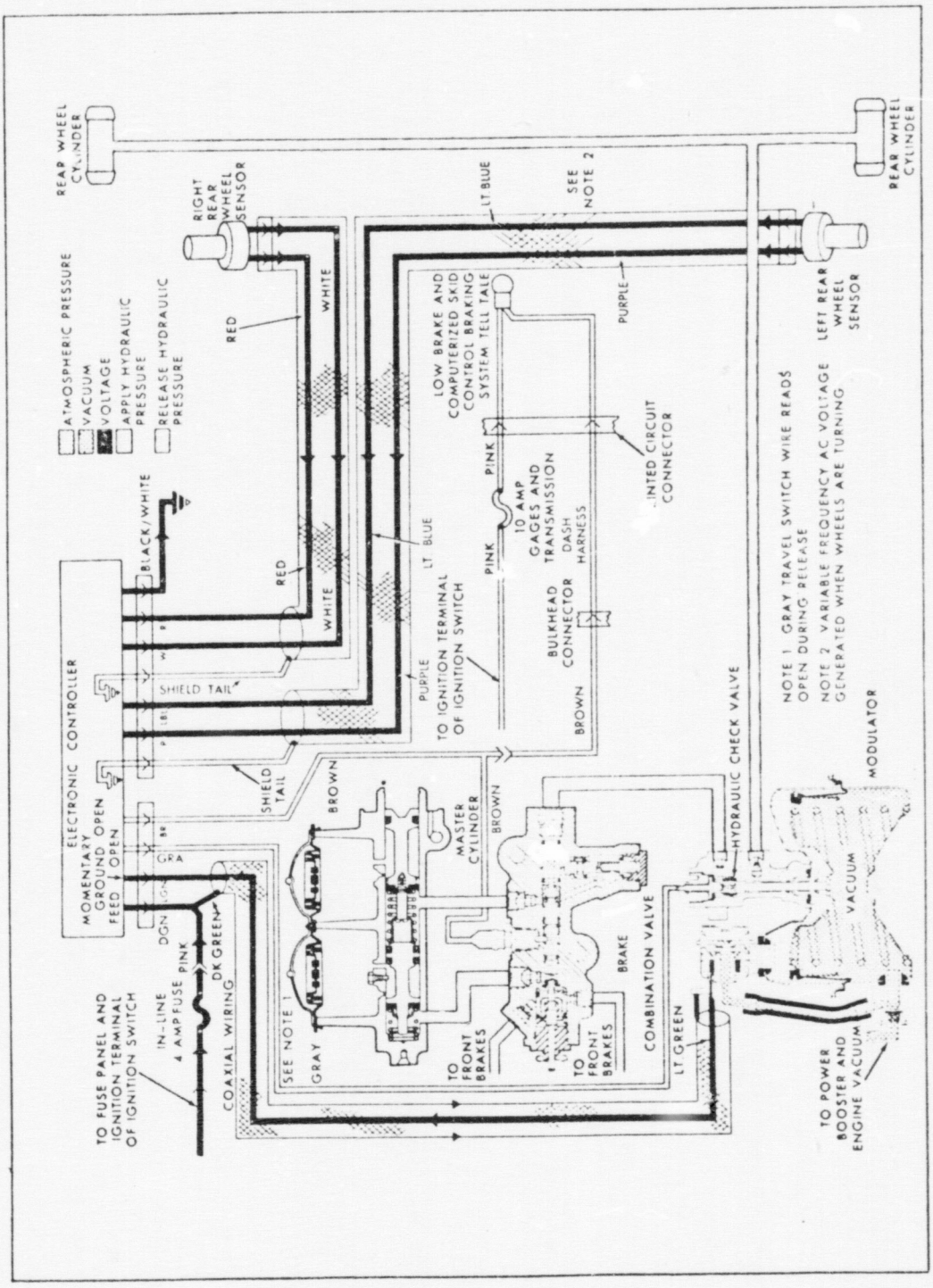



Fig. 5-65 Operation-Release Mode-Eldorado

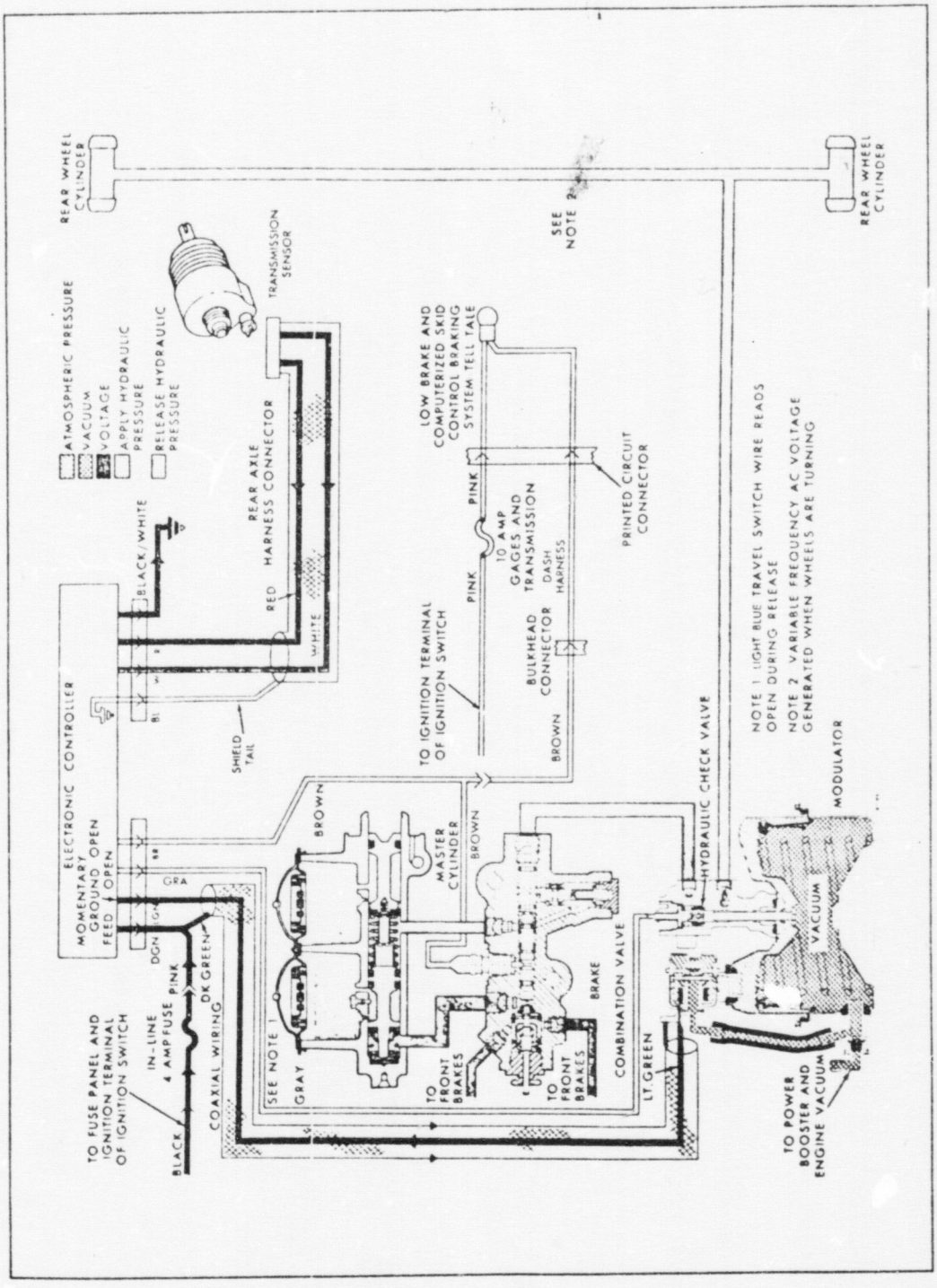



Fig. 5-66 Operation-Release Mode-Exc. Eldorado

## Operation—Normal Brake Stop (Fig. 5-63 and 5-64)

During normal driving conditions an a.c. voltage is sent by the wheel sensors to the controller. When the controller is not sensing an impending wheel lock-up, the modulator vacuum solenoid is without a ground circuit and normal brake apply pressure is transmitted to the rear wheel cylinders.

## Operation—Release (Fig. 5-65 and 5-66)

When the controller senses an impending wheel lock-up, one side of the modulator vacuum solenoid is switched through the light green wire to ground potential in the controller and the modulator solenoid is energized. This action creates a sealed hydraulic circuit between the check valve and the rear wheel cylinders.

The modulator displacement piston moves slightly to increase the rear brake line volume resulting in a decrease in pressure to the rear wheel cylinders, thereby alleviating the lock-up tendency.

## Operation—Exercise Cycle

Each time the ignition switch is turned on, a momentary ground is created in the transistorized circuitry of the controller, energizing the modulator solenoid. An audible noise accompanies this exercising cycle.

## 35. Major System Components

### Eldorado

1. Wheel speed sensor installation is illustrated in Fig. 5-80. The sensor is mounted into the rear wheel backing plate and secured with a screw. Since the rear wheels of a front-wheel drive vehicle rotate independently, one wheel speed sensor is required for each rear wheel. The outputs of the sensors are electronically combined in the controller. A view showing the sensor installed is illustrated in Fig. 5-67. The sensors are serviced only as complete assemblies.

### Except Eldorado

2. Transmission Speed Sensor (Fig. 5-68) – The Transmission Speed Sensor installation is illustrated in Fig. 5-82. The sensor mounts in the transmission in place of the speedometer driven gear assembly. Both the driven gear and flexible shaft coupling are integral parts of the sensor. Since the rear wheels of a rear-wheel drive vehicle are connected through the differential and transmission, the one Transmission Speed Sensor produces an effective speed signal. With 90 teeth on the stator, 15-inch wheels, and a gear ratio of 1.33:1, the resulting transmission sensor output frequency is 25 Hz (cycles) per mph of vehicle speed. A section view showing the internal parts and construction is illustrated in Fig. 5-69.

#### b. Controller

The controller is the electronic computer in the Track Master System. An outline and section view of the controller are illustrated in Fig. 5-70. This unit contains a hybrid electronic circuit comprising discrete components, a printed circuit board, and a ceramic circuit utilizing thick film technology along with flip chip semiconductors. The circuitry is covered with a protective coating and encased in a plastic housing. Electrical connections are made to the car harness by plug-in connectors.

The controller receives and continuously monitors the input speed signals from the two wheel speed sensors in the case of a front-wheel drive vehicle, or the transmission speed sensor in the case of a rear-wheel drive vehicle. Its basic functions are to determine from the input speed signal when rear wheel lock-up is impending, to generate an electrical output to make a ground circuit which automatically partially releases the rear brakes, to determine when the impending rear wheel lock-up situation ceases to exist, and to remove the output signal and ground which again applies the rear brakes.

The controller accomplishes its basic functions by modifying the wheel speed or transmission speed signal to form a second signal simulating vehicle speed. Both wheel speed or transmission speed and vehicle speed signals are then compared. When their difference increases to a predetermined value, the controller generates the output signal making a ground circuit which releases the rear brakes, with reduced rear braking, wheel speed or transmission speed increases, and when the difference between the wheel speed or transmission speed and vehicle speed signals decreases to a predetermined value, the controller removes the output ground signal, thereby increasing rear braking. This process is repeated as required until the vehicle speed decreases to about 5 mph, or until the brakes are released by the driver.

The controller also contains special circuitry which is used in conjunction with the brake warning light to signal most system malfunctions. The controller is serviced as an assembly.

#### c. Modulator

The modulator as pictured with the integral solenoid valve in Fig. 5-71 is mounted on the left side of the cowl. In response to the atmospheric air input from the solenoid valve, its basic function is to control or pulse the hydraulic pressure to the rear brakes during maximum braking stops, similar to pumping the brake pedal with your foot.

Figs. 5-72 and 5-73 are section views of the modulator showing the position of the component parts during normal braking and the release mode, respectively. These figures illustrate the component parts and construction of the modulator which is basically a spring-loaded vacuum operated diaphragm actuator. The support plate operates a displacement piston and hydraulic check valve which controls the rear brake pressure. The piston also operates the travel switch. Also included as parts of the overall modulator assembly are a vacuum check valve and solenoid valve. Electrical connections are made to the solenoid valve and travel switch, engine vacuum is connected to the vacuum check valve, and



[PX 156, p 5-56]

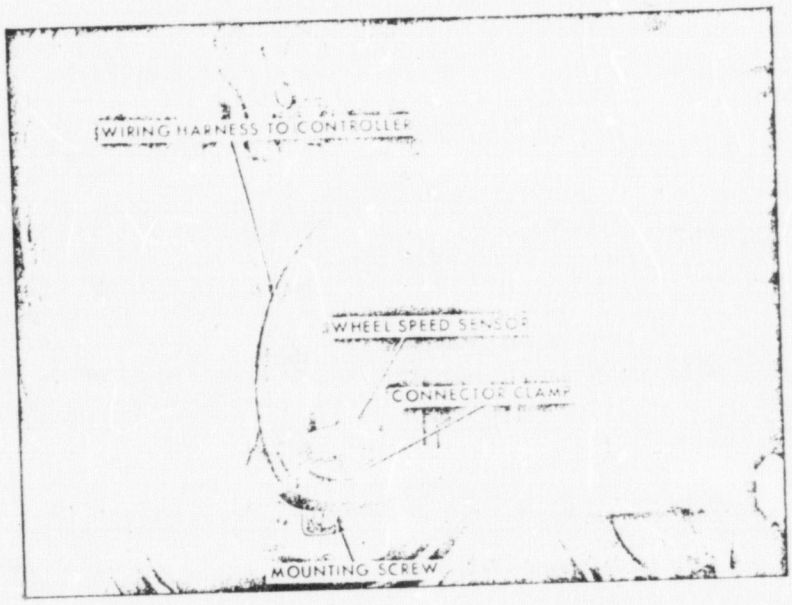



Fig. 5-67 Wheel Speed Sensor

hydraulic connections are made to the rear brakes (outlet port) and brake combination valve (inlet port).

During normal braking, Fig. 5-72, engine vacuum is connected through the vacuum check valve to one side of the diaphragm and through the solenoid valve to the other side of the diaphragm. With the same pressure on both sides of the diaphragm, the spring holds the diaphragm and piston at the top of the modulator. The piston holds the hydraulic check valve open and connects the hydraulic pressure from the brake combination valve to the rear brake wheel cylinders. In the release mode, Fig. 5-73, the vacuum connection through the solenoid valve is blocked by the armature plate and atmospheric air is connected through the solenoid valve to one side of the diaphragm and support plate. The resulting differential pressure creates a force opposing the spring force and pulls the diaphragm and piston toward the bottom of the modulator. When the piston moves down, the hydraulic check valve closes and seals off the master cylinder pressure from the rear brake wheel cylinders. Further movement of the piston increases the volume of the rear brake lines which reduces the rear brake pressure.

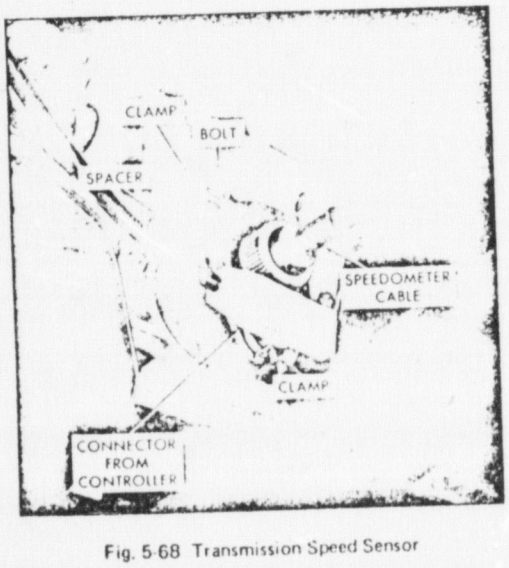



Fig. 5-68 Transmission Speed Sensor

### d. Solenoid Valve

The solenoid valve is a three-way vacuum valve which is operated by the electro-magnetic action of a solenoid. It is mounted through a grommet as an integral part of the modulator. Sensing that rear wheel lock-up is imminent, the controller sends an electrical signal to the solenoid valve. Its basic function is to convert this electrical signal into a pneumatic signal which is used by the modulator.

Fig. 5-74 is a section view of the solenoid and illustrates the internal parts, construction, magnetic operation, and pneumatic operation. There are two inputs to the valve. Atmospheric air is supplied through the cover at port "A" and engine vacuum is supplied through a hose connection at port "V". These two pneumatic inputs may be alternately connected to the modulator through output port "O" by the action of the valve.

With no electrical signal supplied to the solenoid, there is no magnetic action. The spring pushes the armature plate against the apply mode O-ring seal. This blocks the flow of atmospheric air through port "A" of

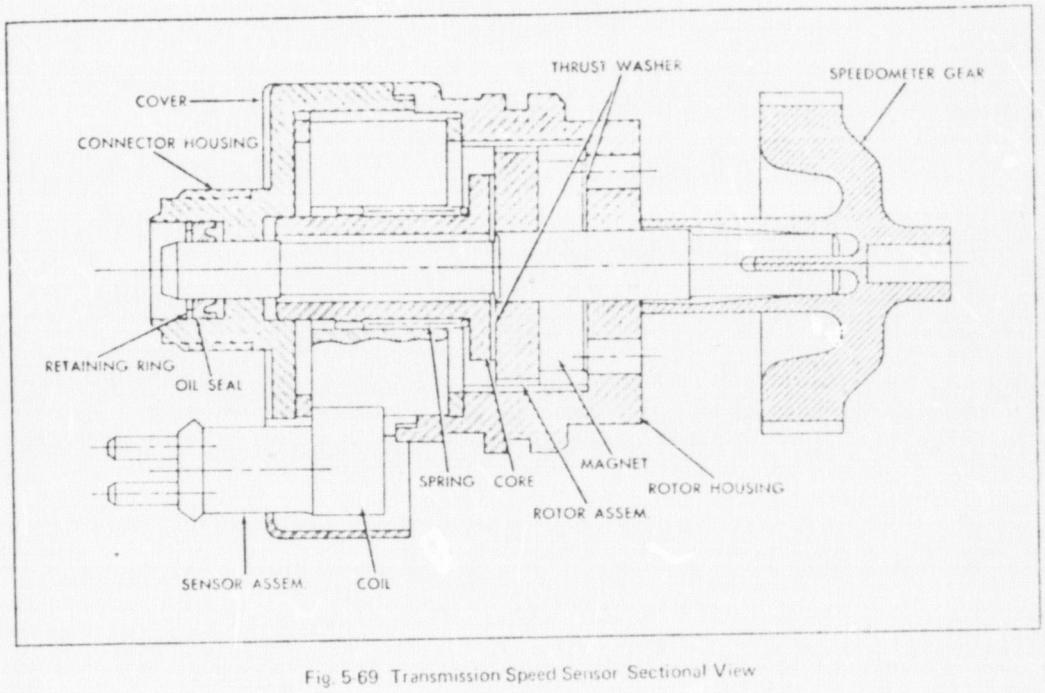



Fig. 5-69 Transmission Speed Sensor Sectional View

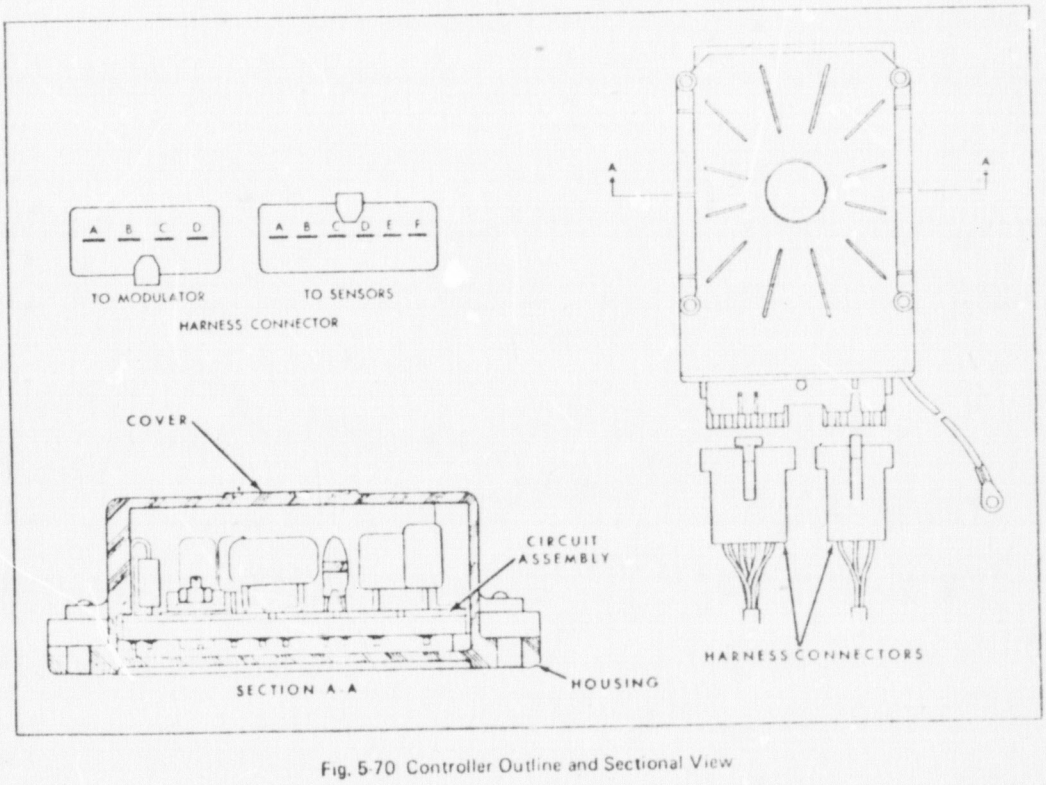



Fig. 5-70 Controller Outline and Sectional View

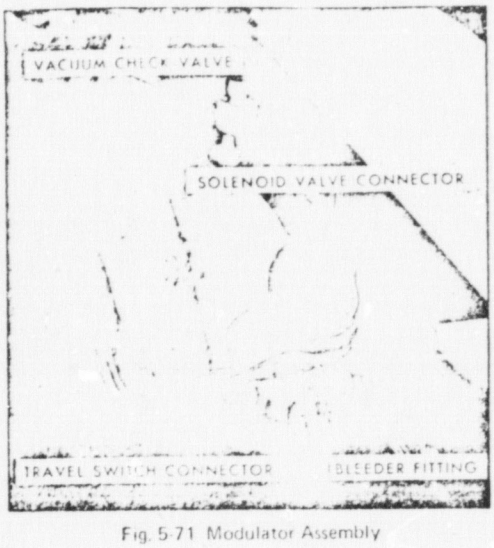



Fig. 5-71 Modulator Assembly

the solenoid and allows vacuum to draw air through the vacuum valve from the top side of the modulator diaphragm, from port "O" to port "V". When the solenoid valve receives an electrical signal from the controller, the magnetic action of the solenoid opposes the spring and pulls the armature plate against the release mode O-ring seal. This blocks the vacuum supply to one side of the modulator diaphragm and allows the modulator to draw atmospheric air through port "A" of the solenoid and supply it to port "O".

The resulting action of the modulator is to release the rear brakes. During a maximum braking stop, the solenoid valve will continue to cycle, alternately supplying air or vacuum to the modulator, until the vehicle speed is less than five miles per hour or until the brakes are released by the driver.

### e. Brake System Warning Light

The brake system warning light, located in the instrument panel, normally indicates that the brake system has sustained a loss of hydraulic pressure to either the front or rear brakes. The bulb and circuit are checked with the ignition switch in the "START" position, where the brake light should be illuminated.

For vehicles equipped with the Track Master option, the brake system warning light also operates in conjunction with the modulator travel switch and special circuitry in the controller to provide a visual indication to the driver in the event of most Track Master System malfunctions. When the travel switch is open more than approximately four seconds (except during a skid controlled stop), the controller turns the tell-tale light on. An exception to this is an open in the 4 amp feed circuit from the ignition switch, which is indicated without the four second delay. When a malfunction is detected, the warning light is illuminated and remains illuminated un-

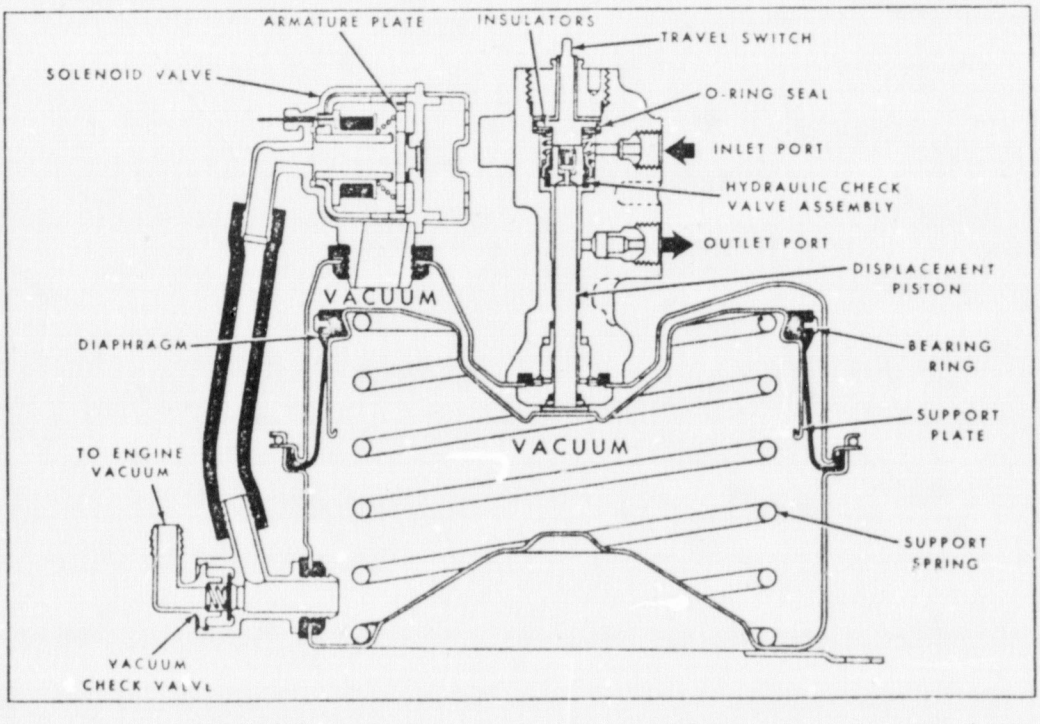



Fig. 5-72 Modulator Assembly-Normal Braking

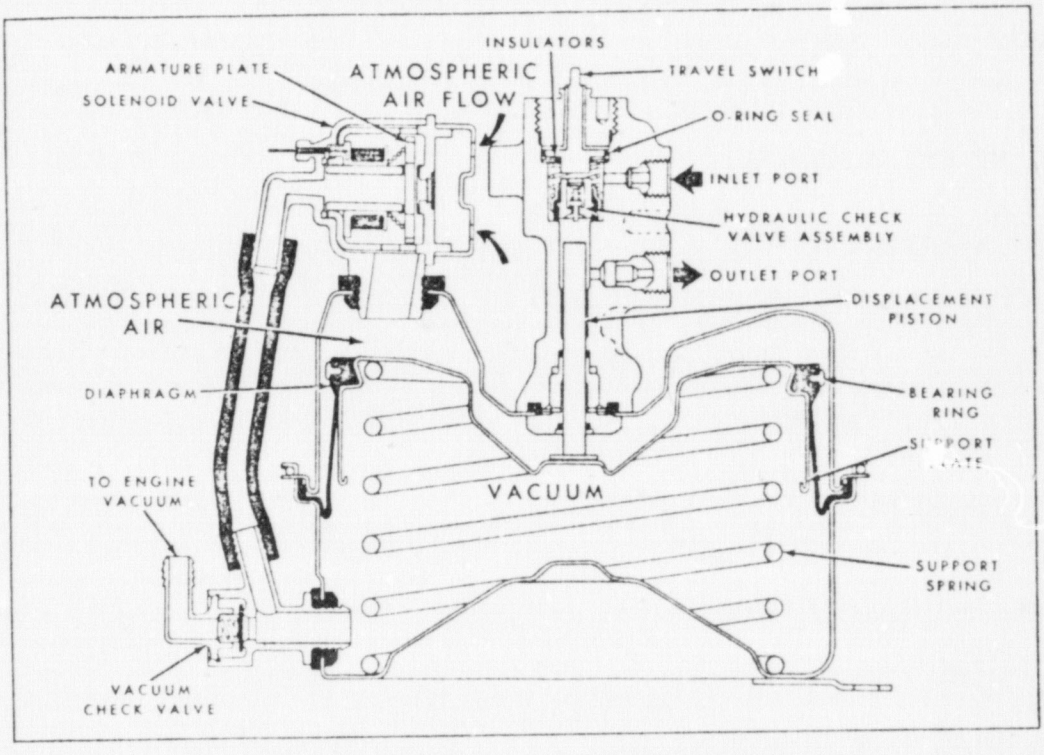



Fig. 5-73 Modulator Assembly-Release

til the ignition switch is turned off. Any malfunction indication requires immediate service to the hydraulic system or Track Master System.

In the event of many types of malfunctions, the rear brake operation automatically reverts to a standard system; i.e., normal operation without the Track Master System option. For certain malfunctions, the restoration of standard brakes is accomplished by a special controller circuit which prevents the generation of an output brake release signal whenever a malfunction indication signal exists in the brake system warning light circuit.

### f. Electrical Harness

1. The Eldorado Track Master System wiring harness consists of three main sections: rear axle harness, which runs from the rear wheel sensors to a rear axle harness connector; front harness running from the rear axle harness connector to the controller; and a controller and modulator harness, running from the controller to the ignition circuit and modulator.

Connectors for the speed sensors and solenoid valve are molded waterproof-type with appropriate clamps to insure sealing.

(NOTE: Connectors to the speed sensors must be packed with front wheel bearing grease as well as clamped.)

2. The C-car Track Master wiring harness consists of a body harness running from the transmission sensor to the controller; and a controller and modulator harness, running from the controller to the ignition circuit and modulator.

The solenoid cable is unique in that it has a single conductor with a braided copper shield and insulating jacket. Contrary to usual practice, the shield is not at ground potential, but is at battery potential. This has been done so that if the solenoid cable is shorted, the control system fuse will blow and the brake system will function in a standard manner. If the system were not designed to blow the fuse, a short in the ground side of the solenoid circuit (light green wire) would keep the rear brakes continuously released.

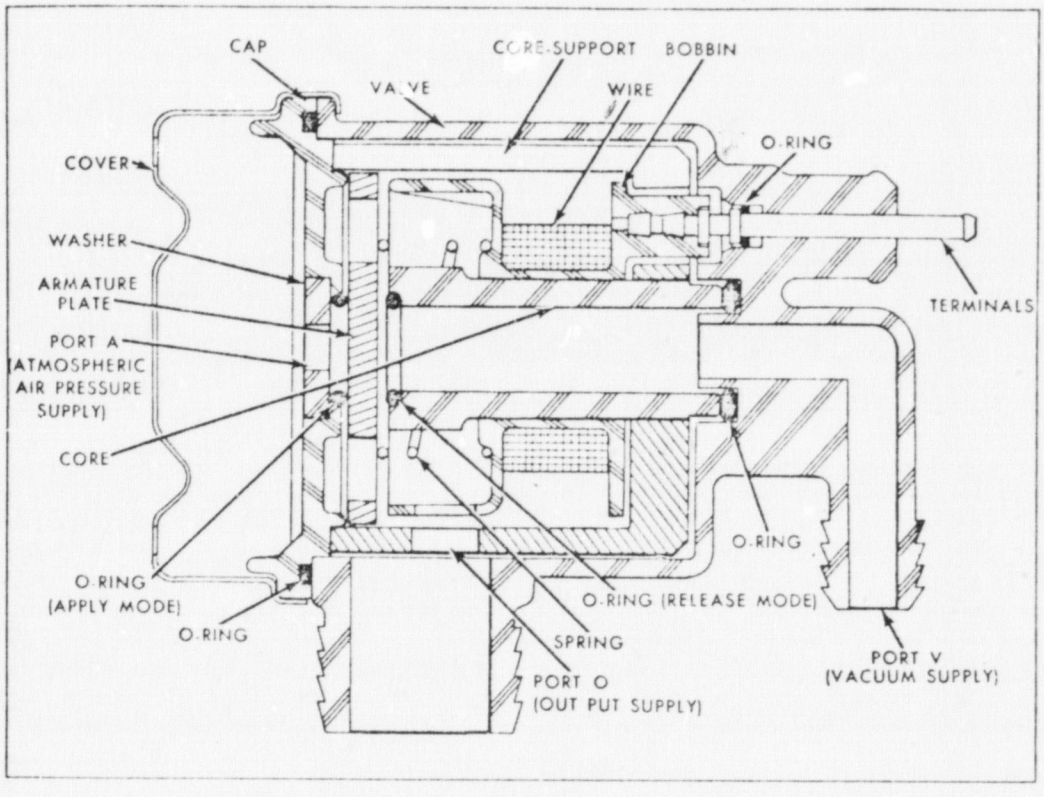



Fig. 5-74 Section View-Solenoid

# DIAGNOSIS

## 36. Diagnosis

### a. How to Use Diagnosis Guide

The operation of the brake tell-tale light is important when analyzing a Track Master problem. Any abnormal brake light indication means there is a problem in the hydraulic system or the Track Master System. In addition, if the light does come on, it is important to know if turn on is immediate or there is a delay. The lack of an exercise cycle or the presence of pseudo cycling also indicates a Track Master problem. The diagnosis guide, in large part, is based on these four underlined characteristics and a definition for each is listed in Part b.

Most problems will fall into one of these conditions. However, the system may exhibit none of the four failure characteristics and still not cycle during an impending wheel lock.

If an owner complains of this situation, the only recourse is to observe the operation under wheel lock conditions. Part c is a test used to simulate wheel-lock so the operation of the system may be observed.

After it is positively determined that a problem exists, the first step is to remove the system in-line 4 amp fuse, disconnect both controller connectors and use an ohmmeter to check for the presence of open or short circuits as described in Part d.

The diagnosis guide, Part 3, is keyed to information obtained in Parts b, c, and d.

### b. Definitions

Definition of "Immediate" Brake Light:

The brake light comes on immediately when the ignition switch is turned to the "ON" position.

Definition of "Delayed" brake Light:

A delayed brake light comes on two to five seconds after the ignition switch is turned to the "ON" position.

When a delayed brake light is encountered, it is normally the result of the Track Master self-check circuitry detecting a problem in the system. When this occurs, the self-check circuit latches off the Track Master

and latches the brake lamp on. Finding the problem and taking corrective action at this time (with the ignition on) will not result in the brake light going off, as it is latched on. In order to reset the Track Master self-check circuit and turn the brake lamp off, it is necessary to turn the ignition off. After doing so, it may be again turned on and the engine started, to evaluate the corrective action and/or continue the diagnosis procedure.

Definition of Exercise Cycle:

Each time the ignition switch is turned on, the Track Master controller sends a short signal to the modulator assembly. This signal energizes the solenoid valve, which in turn allows the modulator to partially cycle if there is vacuum in the system. This exercise cycle can be detected audibly or by feeling the modulator while someone turns the ignition switch on; however, the only positive way to determine if the exercise cycle is normal is to check it with vacuum in the system (running engine for a few seconds will provide sufficient vacuum) and with an ohmmeter connected from the modulator travel switch terminal to ground. If the ohmmeter reading indicates that the modulator travel switch has changed from "closed" to "open" and back to "closed" again when the ignition switch is turned to the "on" position, the exercise cycle is normal.

Definition of Pseudo Cycling:

The Track Master System's basic function is to maintain vehicle stability during maximum effort stops by keeping the rear wheels from skidding. This action can take place at varying degrees of brake pedal effort as determined by brake effectiveness, slipperiness of road surface, etc., and normal cycling will be experienced when the controller senses the rear wheels starting to lock up. This is "normal" operation. Cycling of the system, random or otherwise, when not braking the vehicle or when light (normal) brake stops are being made would be considered "pseudo cycling".

### c. Operational Check

1. C-Car – Raise and support rear end of vehicle so the rear wheels are above the floor. Start the engine, shift into "drive" range and accelerate wheels to approximately 40 mph (speedometer). Apply the brake firmly and observe the speedometer. The speedometer should reflect the cycling of the rear wheels and should gradually approach 0 mph. Also, the cycling of the rear wheels normally can be felt as well as heard. If the speedometer goes directly to "0" mph from 40 mph when the brake is applied, the wheel lock control system is inoperative.

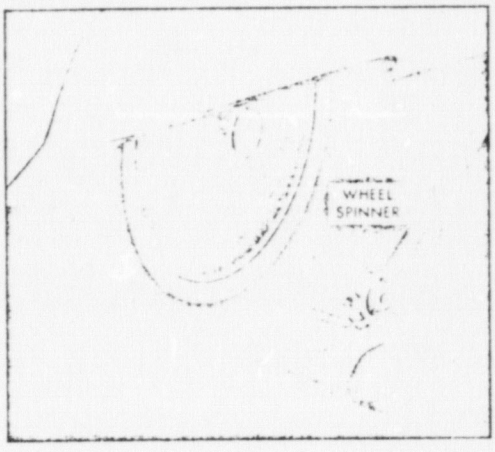



Fig. 5-75 Rotating Wheel

2. Eldorado – Raise and support rear end of vehicle so that rear wheels are above the floor. Start the engine. Use the following procedure for each rear wheel: rotate wheel at high speed using wheel spinner of Dynamic Wheel Balancer, Fig. 5-75. Remove drive motor from wheel, apply brake firmly and observe rear wheel for cycling. If wheel stops immediately after application of foot brake, system is not operating normally.

### d. Controller Connectors Check (Fig. 5-64)

Resistance and continuity checks should be made at the harness connectors with the controller disconnected, and with the Track Master System power lead disconnected at the 4 amp in-line fuse. Normal readings are shown in Fig. 5-76 and 5-77.

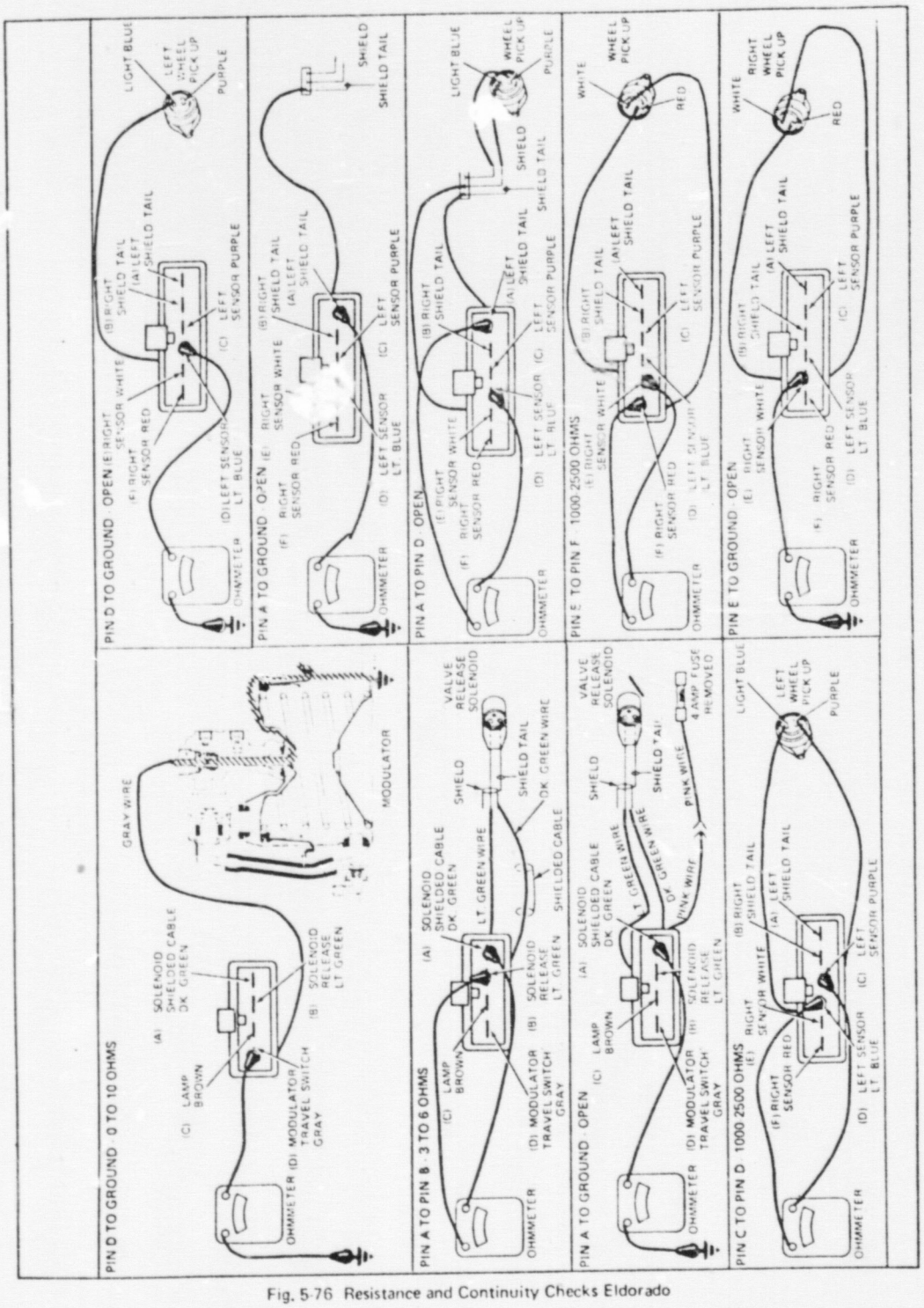



Fig. 5-76 Resistance and Continuity Checks Eldorado

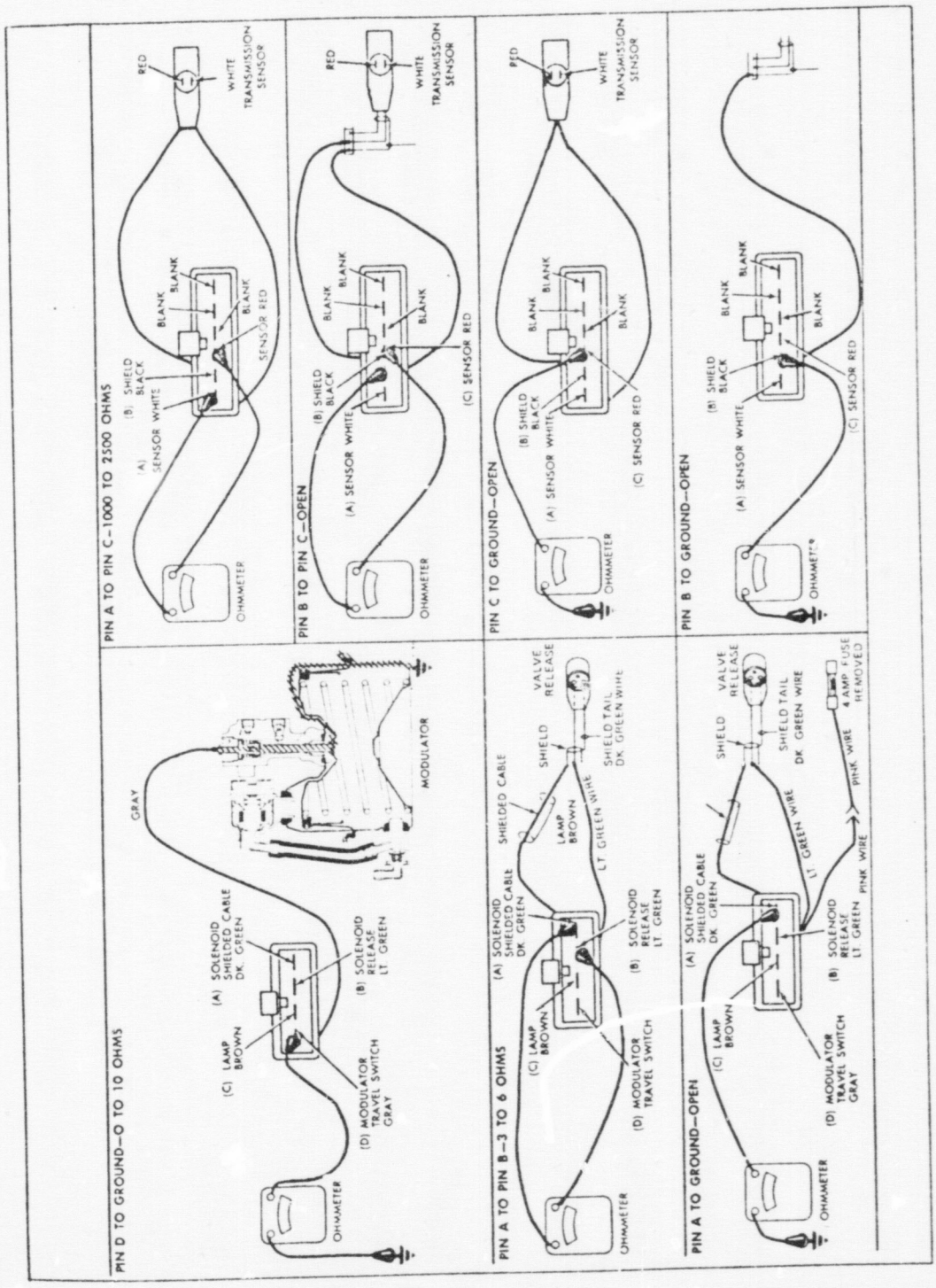



Fig. 5-77 Resistance and Continuity Checks Exc. Eldorado

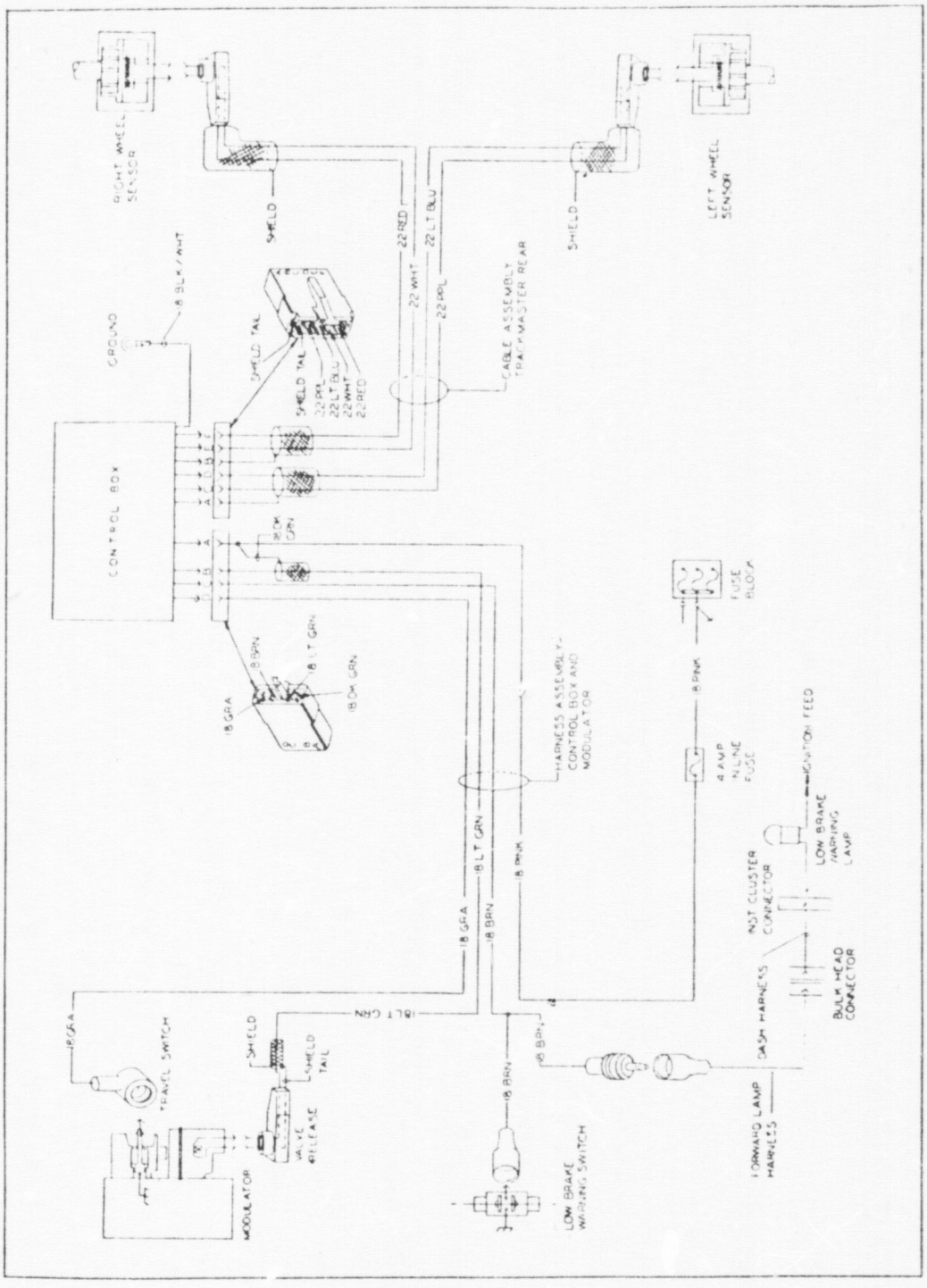



Fig. 5-78 Circuit Diagram-Eldorado

[PX 156, p 5-67]



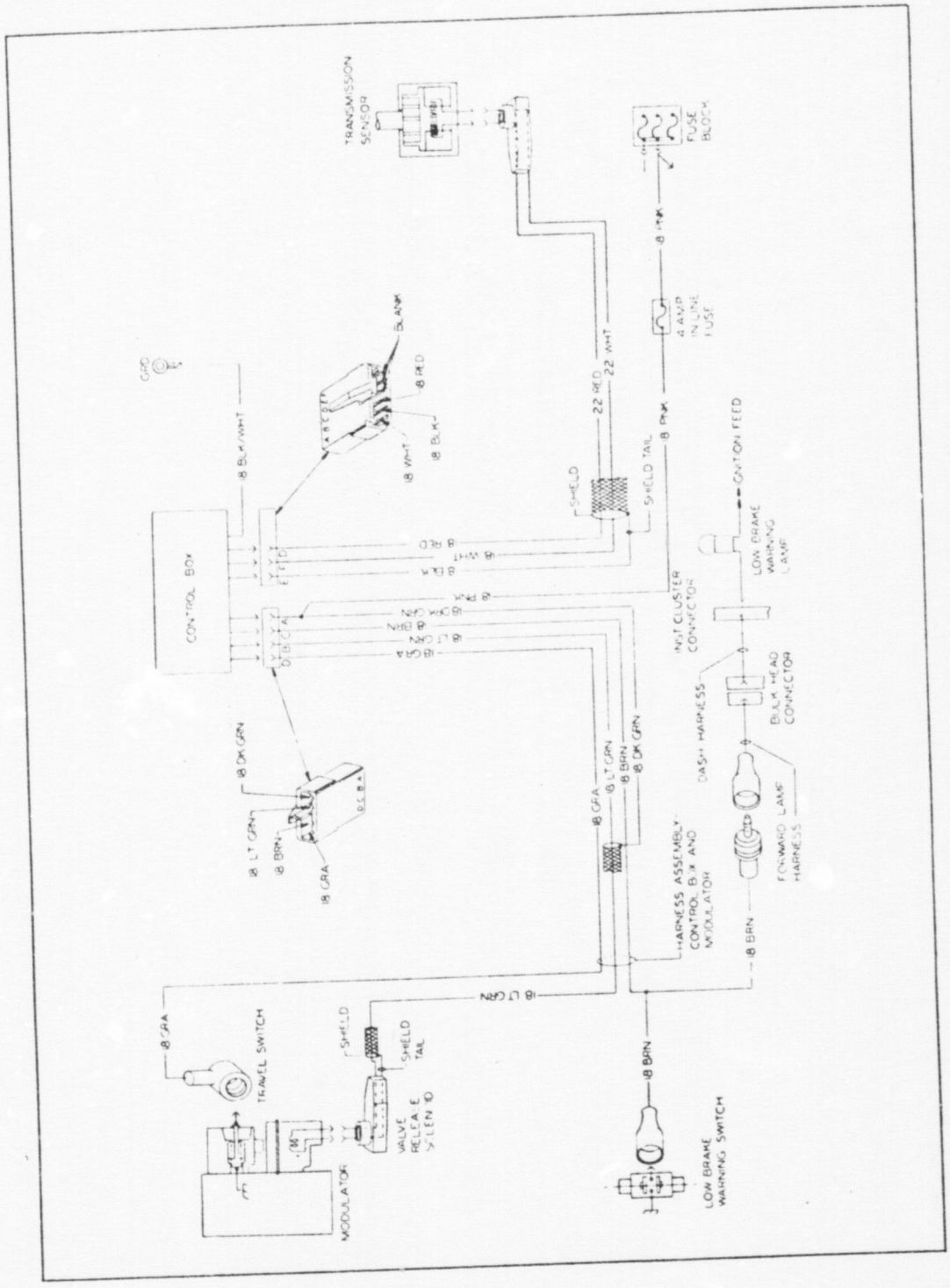



Fig. 5-79 Circuit Diagram-Exc. Eldorado

Diagnosis Guide

| CONDITION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| No brake light under any condition (check by placing ignition in "START") | Burned out lamp (bulb). | Check for cause. Replace bulb. |
| | Blown 10 amp trans - gage fuse | Check for cause. Replace fuse. |
| | Open electrical leads to brake lamp circuit. | Check for continuity of leads and correct accordingly. |
| Immediate brake light when ignition switch is turned "ON") | Leak in hydraulic system. | Check by removing lead from brake combination valve. If light goes out, a leak in hydraulic system is indicated. |
| | Track Master fuse blown. (Track Master inoperative) | Check harness & connector for cause of blown fuse and correct. Replace fuse. (See remaining causes in this group also) |
| | Shorted solenoid lead to ground-blows Track Master fuse. (Track Master inoperative) | Repair or replace harness. |
| | Shorted solenoid (blows Track Master fuse, Track Master inoperative) | Replace solenoid. |
| | No +12 VDC at Track Master controller. (Faulty connections or open circuit in wiring - Track Master inoperative) Track Master controller faulty. | Check feed wire (pink) and connectors. Correct as necessary. |
| | Track Master controller faulty. | Replace controller. |

FOR THE FOLLOWING CONDITIONS: It is assumed that the brake lamp circuit operates normally and there are no hydraulic leaks or air trapped in the brake system.

| CONDITION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| No brake light. Track Master completely inoperative but exercise cycle OK. (Ignition switch "ON" or engine running.) | Transmission sensor seized or not being driven. | Check speedo gear and replace if necessary. Check for cause of seizing and replace. |
| | Eldorado sensor not close enough to teeth or rear hubs. | Check for cause and adjust if necessary. |
| | Both speed sensor leads shorted to each other (but not shorted to ground) | Disconnect speed sensor connectors.<br>a. Check resistance across speed sensor terminals. (Should be 1000-2500 ohms). If out of limits, replace speed sensor. (Pack sensor connectors with wheel bearing grease.)<br>b. Remove connectors to controller. Check resistance across terminals at speed sensor connector. Should be infinite (open). If not, repair or replace harness. |
| | Track Master controller faulty. | Replace controller. |

| | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| No brake light. Track Master completely inoperative and no exercise cycle (ignition switch "ON" or engine running). | Loss of ground connection to Track Master controller. | Check ground lead connection from controller. (Black/white wire) |
| | Controller connector not plugged into controller and modulator harness. | Plug in connector. |
| | Solenoid valve seized in de-energized position. | Disconnect solenoid lead. |
| | | a. Momentarily apply 12 volts to solenoid terminals and listen for solenoid core movement (sharp click). If inoperative, replace solenoid. |
| | | b. Apply 12 volts to solenoid terminals for 2-3 seconds and observe if vacuum leak stops after solenoid "clicks" (with engine running). If vacuum leak does not stop, replace solenoid. |
| | Modulator seized in de-energized position. | Disconnect gray modulator travel switch wire. |
| | | Connect ohmmeter from modulator travel switch to ground. With the engine running, pull solenoid valve out of modulator port and observe ohmmeter. If ohmmeter reflects a change from very low resistance to high resistance as the solenoid valve is removed, the modulator is OK. If not, replace the modulator. |
| | Track Master controller faulty. | Replace controller. |
| Brake light comes on after a 2-5 second delay. Track Master completely inoperative but exercise cycle OK. (Ignition switch "ON" or engine running.) | Speed sensor leads open | Check speed sensor connectors and pack with front wheel bearing grease. Secure connection with clamps. |
| | | Disconnect connectors and check continuity across sensor terminals - should be 1000-2500 ohms. If not, replace sensor(s). |
| | | Remove connectors to controller and check resistance across terminals E & F and K & L at harness connector with the speed sensor connector(s) reconnected (should be 1000-2500 ohms) - if open, replace harness. |
| | Speed sensor lead(s) shorted to ground. | Disconnect speed sensor connectors and check continuity of speed sensor terminals to ground. If any terminal is grounded, replace speed sensor. |
| | | Remove connectors to controller. Check continuity of speed sensor connector terminals to ground. If any terminals are grounded, replace harness. |
| | Modulator travel switch open. | Remove gray wire connector from modulator travel switch terminal. Check for 0-10 ohm resistance reading from terminal to ground. If out of limits, replace modulator. |
| | Modulator travel switch connector not making contact with the terminal or open circuit in the lead. | Check gray wire connector at modulator travel switch terminal for security. |
| | | Remove gray wire modulator travel switch connector from terminal and insert jumper from connector to ground. If system now operates |

| CONDITION | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| Brake light comes on after a 2-5 second delay. Track Master completely inoperative but exercise cycle OK. (Ignition switch "ON" or engine running.) (Cont'd.) | Modulator travel switch connector not making contact with the terminal or open circuit in the lead. (Cont'd.) | normally, the travel switch is faulty, requiring modulator replacement. If system is still inoperative, check continuity of modulator travel switch lead. If open, repair or replace harness. |
| | Track Master controller faulty. | Replace controller. |
| Brake light comes on after a 2-5 second delay. Track Master completely inoperative and no exercise cycle. (Ignition switch "ON" or engine running.) | Solenoid lead(s) open. | Check connector at solenoid valve for security.<br>Remove connector and check resistance of solenoid (3-6 ohms). If out of limit, replace solenoid.<br>Remove controller and modulator harness connector at controller. Also disconnect pink 12 volt feed wire to harness by removing in-line 4 amp fuse. Check continuity of terminals C & D, Fig. 5-76 and/or 5-77, at the harness connector with a jumper temporarily inserted across the solenoid valve connector terminals. If open, repair or replace harness. |
| | Track Master controller faulty. | Replace controller. |
| Pseudo cycling while vehicle is in motion. | Frayed shield leads causing intermittent short. | Visually check shields leads and connectors for stray strands of wire. Repair or replace harness as required. |
| | Improperly greased sensor connector or missing clamp. | Pack connector with front wheel bearing grease and clamp connection. |
| | Sensor Damper Deteriorated | Replace sensor. |
| | Bad electrical connections. | Clean connector. |
| | Track Master controller faulty. | Replace controller. |
| Pseudo cycling while vehicle is parked (with engine running or ignition switch "ON"). | Bad electrical connections.<br>Track Master controller faulty. | Clean the connection, pack with front wheel bearing grease and properly clamp connection. |
| Does not cycle down to 5 mph during maximum braking effort stop. | Insufficient operating vacuum.<br>Track Master controller faulty. | Look for severe vacuum leak and correct.<br>Replace controller. |
| Brake light on 2-5 seconds after high brake pressure is applied. | Defective brake combination valve (excessive pressure applied to modulator). | Replace brake combination valve. |

# SERVICE INFORMATION

*CAUTION: Never operate the system unless the controller has a good ground. Never reverse battery polarity and always connect battery booster cables positive to positive and negative to negative.*

## 37. Wheel Speed Sensor (Fig. 5-80) (Eldorado Only)

### a. Removal

1. Raise car on hoist.
2. Remove clamp and connector at sensor.
3. Remove one screw securing sensor to backing plate.
4. Remove wheel speed sensor.

### b. Installation

(NOTE: If new sensor is to be installed it will be furnished with a piece of pressure sensitive tape on the pick-up end. This tape must be left on.)

1. Install sensor in backing plate so that taped end contacts teeth on hub.

(NOTE: Place a .010" blade feeler gage between sensor and hub if no tape is present, Fig. 5-81. When feeler gage is used it will be necessary to remove wheel disc, wheel, and brake drum.)

2. Secure sensor to backing plate with one screw and tighten to 75 inch pounds.
3. Remove feeler gage if used.
4. Install connector packed with front wheel bearing grease. Install brake drum, wheel and wheel cover if removed.
5. Lower car.

## 38. Transmission Speed Sensor (Fig. 5-82)

### a. Removal

1. Disconnect speedometer cable at transmission sensor.
2. Release clamp at harness connector and remove connector.
3. Remove one bolt, retainer and spacer securing sensor to transmission.
4. Remove sensor from transmission.

### b. Installation

1. Install sensor with speedo gear in transmission.
2. Install spacer, retainer and bolt securing sensor to transmission.
3. Install harness connector packed with front wheel bearing grease to sensor and secure with clamp.
4. Connect speedometer cable to sensor.

## 39. Controller

### a. Removal

1. Working under instrument panel below the glove box, remove wiring harness connectors from controller.
2. Remove wiring harness strap from bottom of controller bracket.
3. Loosen two screws securing bracket to instrument panel.
4. Remove one screw securing ground wire to instrument panel and remove controller.
5. Remove two screws securing bracket to controller.

### b. Installation

1. Install controller on bracket and secure with two screws.
2. Install controller on instrument panel and secure with two screws.
3. Secure ground wire to instrument panel with one screw.
4. Install connectors on controller.
5. Install strap securing harness to bottom of bracket.

## 40. Modulator

### a. Removal

1. Disconnect positive battery cable.
2. Using an old fan belt, support hood by the secondary hood release lever with a chain fall.
3. Remove left hand hood hinge. Support left rear of hood with a block of wood.
4. Disconnect travel switch and solenoid connectors at modulator.
5. Remove vacuum hose at check valve assembly.

(NOTE: The only serviceable components of the modulator are the check valve assembly, solenoid assembly and modulator without check valve or solenoid.)

6. Disconnect two brake lines at modulator assembly.
7. Remove three screws that secure modulator to cowl and remove modulator.

### b. Installation

1. Install modulator on cowl and secure with three screws. Tighten screws to 85 inch pounds.
2. Connect solenoid and travel switch connectors.
3. Install solenoid and check valve assemblies with vacuum hoses attached.
4. Secure two brake lines at modulator assembly.
5. Install left hand hood hinge.
6. Release chain fall and remove fan belt from secondary latch.
7. If pressure bleeding equipment is available, proceed to Step 8. If not, proceed to Step 14.
8. Remove master cylinder reservoir cover and seal assembly and fill both reservoirs with brake fluid.
9. Install Bleeder Adapter, J-22489-1 and J-22489-12 cables on master cylinder and connect bleeder hose to Bleeder Adapter Cover.

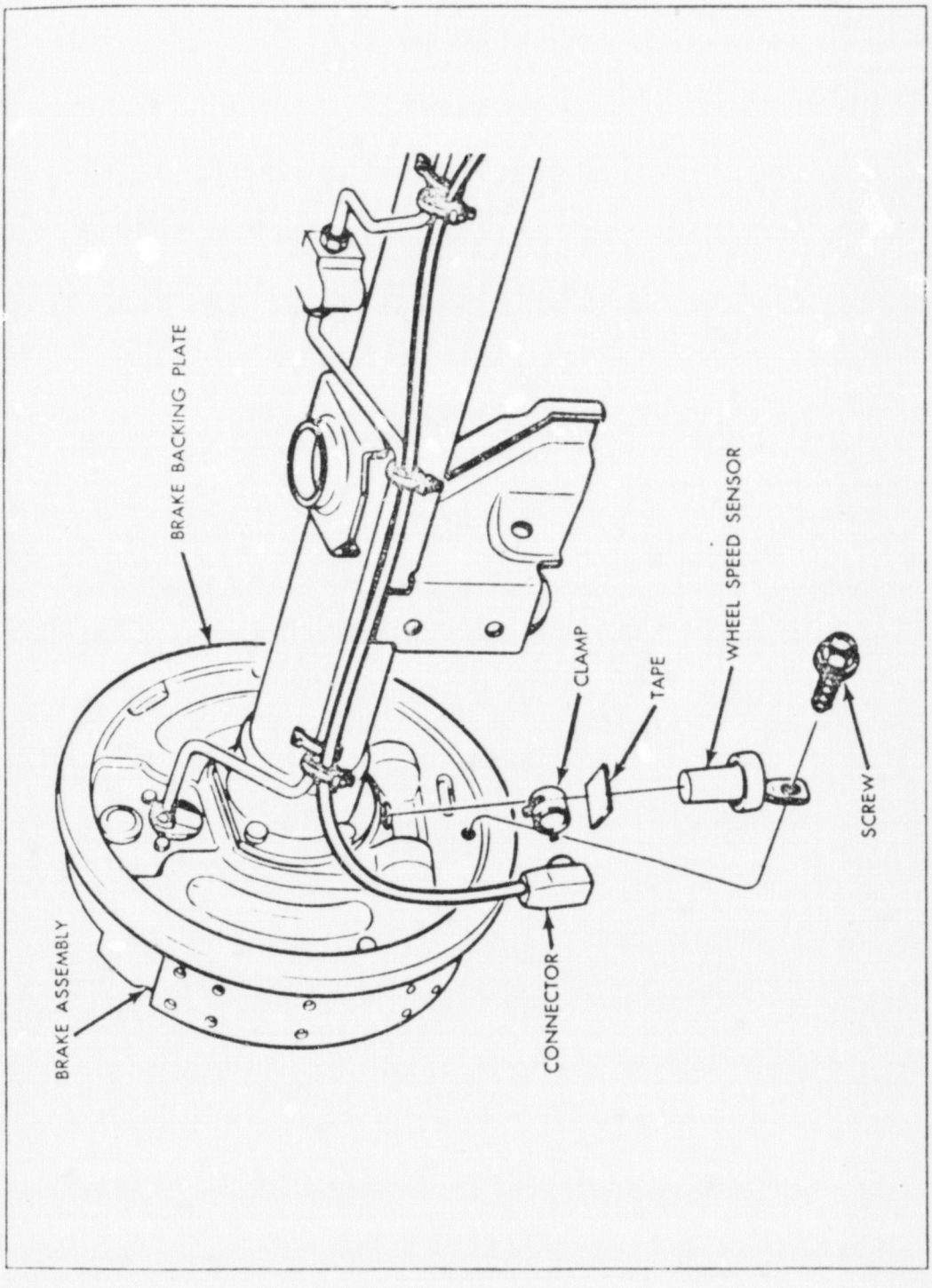



Fig. 5-80 Wheel Sensor Installation

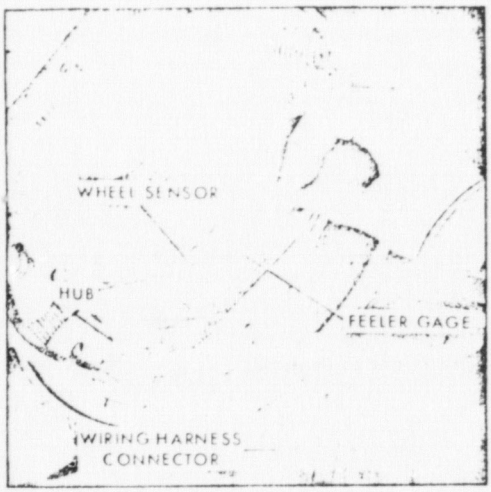



Fig. 5-81 Gaging Wheel Speed Sensor

10. Build up pressure in bleeder 30 psi minimum and bleed system at modulator as described in Steps 11 and 11. Attach drain hose at bleeder fitting.

12. Back off fitting one-half turn and bleed brake fluid into a partially filled bottle of clean brake fluid until bubbles stop, then close fitting.

13. Raise car on hoist and first bleed right rear and then left rear brake following procedure outlined in Steps 11 and 12. Proceed to Step 17.

14. If a pressure bleeder is not available the following two man procedure may be used to bleed the rear brakes. Fill both master cylinder reservoirs with brake fluid.

(NOTE: Keep reservoirs at least partially filled at all times during bleeding operation)

15. Bleed system at bleeder fittings in the following order: modulator; right wheel; left wheel; using procedure described in Step 16.

16. Attach drain hose to bleeder fitting. Apply pressure to brake pedal, back off fitting one-half turn, and depress brake pedal. Close bleeder fitting before releasing pressure on brake pedal. Repeat applications until bubbles stop.

17. Master cylinder reservoir level should be 1/8" to 3/8" from top. Before driving car, be sure a firm pedal is obtained.

18. Connect positive battery cable.

## 41. Solenoid

### a. Removal

1. Remove Vacuum hoses.
2. Remove solenoid connector.
3. Remove solenoid.

### b. Installation

1. Install solenoid on modulator, securing two vacuum hoses.
2. Install solenoid connector.

## 42. Harness Repair

When damage occurs to the modulator harness, it will be necessary to make an evaluation as to whether this damage should be repaired by use of a splice and rosin core solder or by replacement.

In the case of the front harness, correction should be made by repair since this harness is difficult to remove and install. No attempt should be made to repair the rear harness due to the critical need for sealing.

Figure 5-83 illustrates proper soldering techniques to be followed. If a repair is to be made, it will be necessary to snip out the trouble area. The inner wire(s) should then be joined in a parallel splice and may be secured with a mechanical crimp, as illustrated, or soldered. The braided shield is also joined in a parallel splice and soldered. Each inner wire is then taped so it cannot short. Finally, the shield and inner wire(s) are both covered with tape.

## 43. Rear Axle Harness (Eldorado Only) (Fig. 5-84)

### a. Removal

1. Raise car on hoist.
2. Remove plastic straps securing harness to frame and rear axle.
3. Disconnect harness connectors.
4. Disconnect speed sensor connectors from speed sensors.
5. Remove harness.

### b. Installation

1. Pack speed sensor connector with grease.
2. Position harness and install speed sensor connectors on speed sensor securing with clamps.
3. Connect harness connectors.
4. Install plastic straps securing harness to rear axle and frame.
5. Lower car.

## 44. Controller and Modulator Harness

### a. Removal

1. Disconnect solenoid and travel switch connectors at modulator.
2. Disconnect brown wire at underhood harness connector on left wheelhouse.
3. Remove top screw and loosen lower screw securing grommet retainer to firewall and remove split grommet. Push harness through cowl.
4. Remove upper instrument panel cover as described in Section 12, Note 40a.
5. Route harness to top of instrument panel area.
6. Disconnect single pink wire connector that leads to fuse block.
7. Disconnect four-way controller connector.
8. Remove controller and modulator harness.

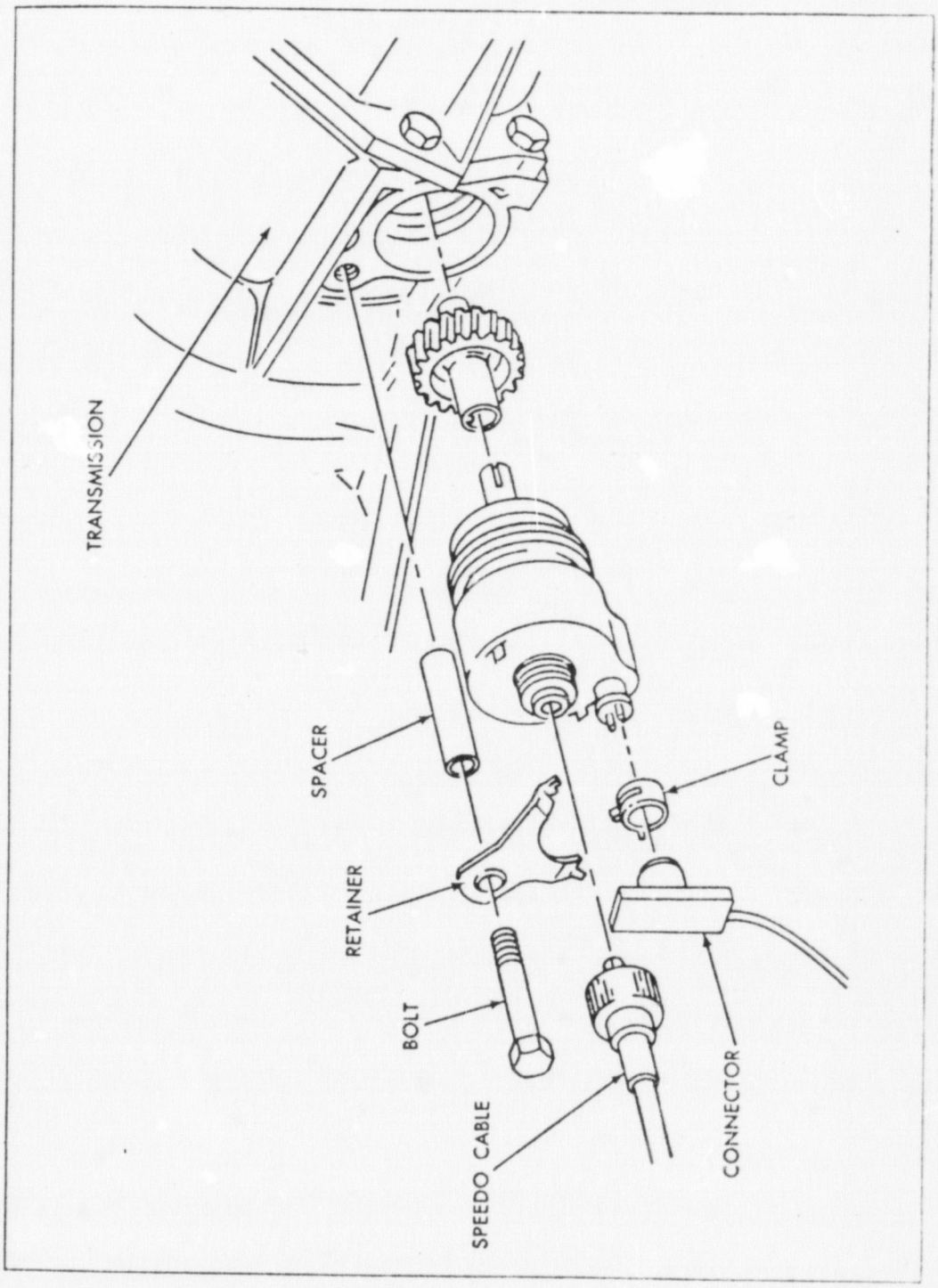



Fig. 5-82 Transmission Sensor Installation

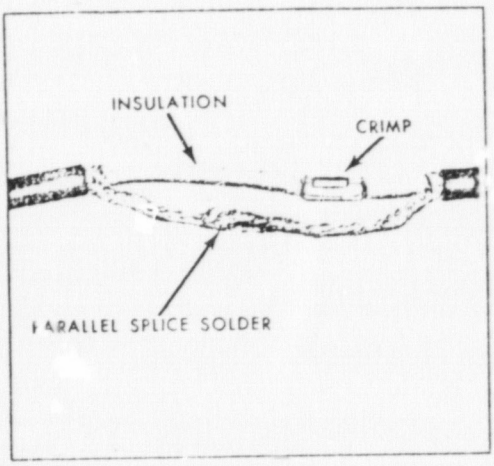



Fig. 5-83 Shielded Cable Repair

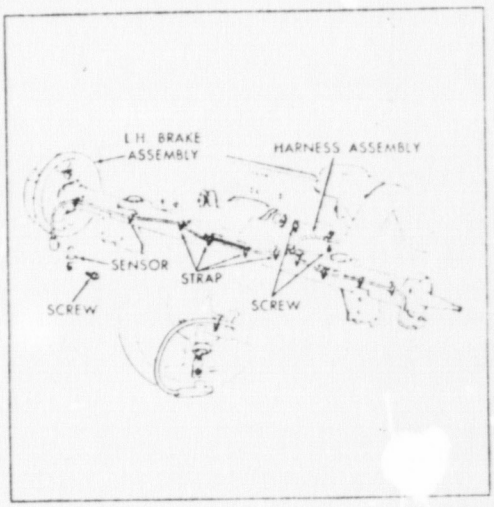



Fig. 5-84 Securing Harness to Axle-Eldorado

**b. Installation**

1. Position harness on top of instrument panel area and route to pink lead to controller.
2. Connect four-way controller connector.
3. Connect single pink wire connector that leads to fuse block.
4. Route harness through cowl.
5. Connect solenoid and travel switch connectors at modulator.
6. Connect brown wire connector at underhood harness connector on left wheelhouse.
7. Install split grommet in retainer and install top screw and tighten lower screw securing grommet retainer to cowl.
8. Install upper instrument panel cover as described in Section 12, Note 40b.

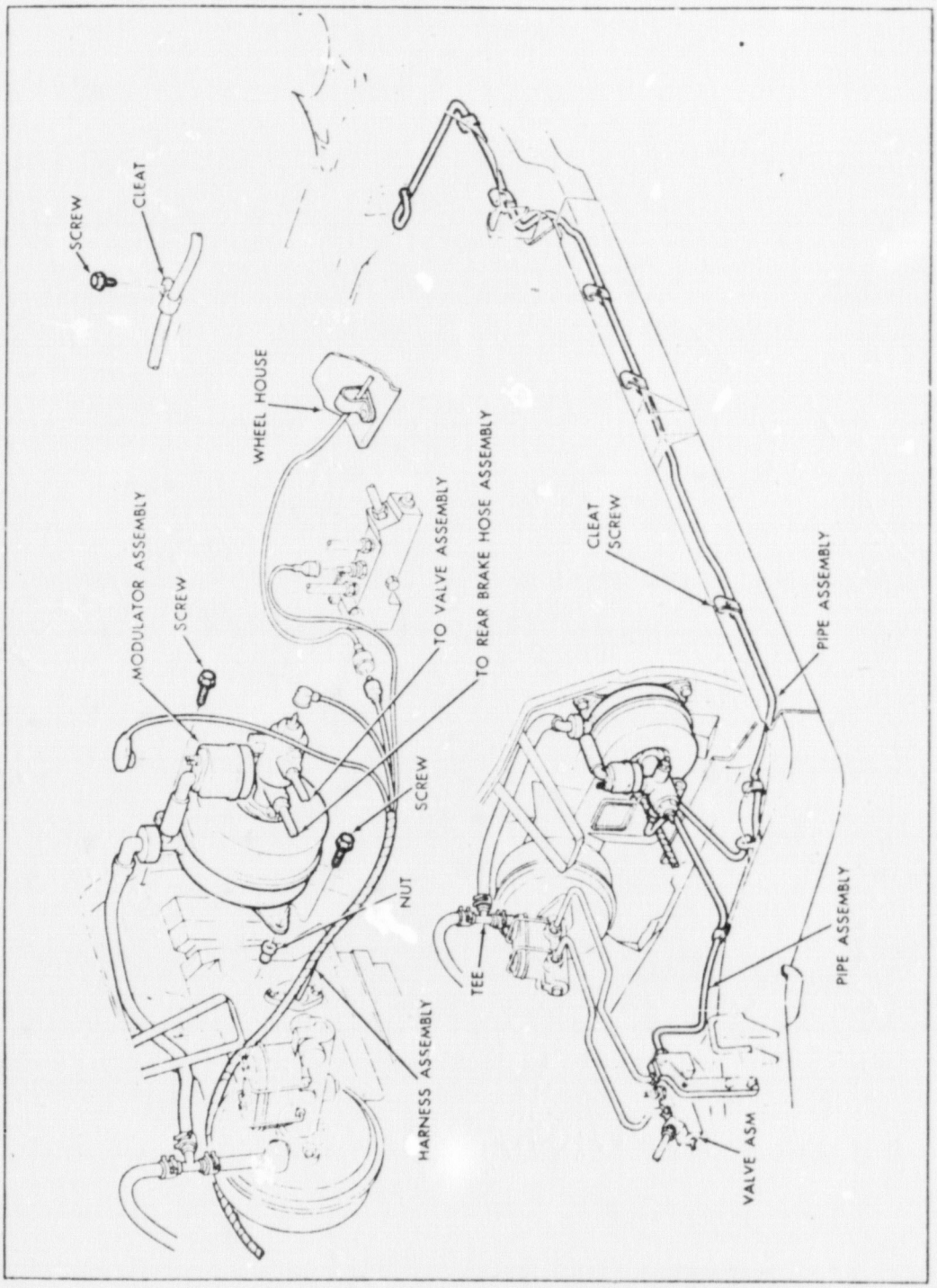



Fig. 5-85 Track Master-1

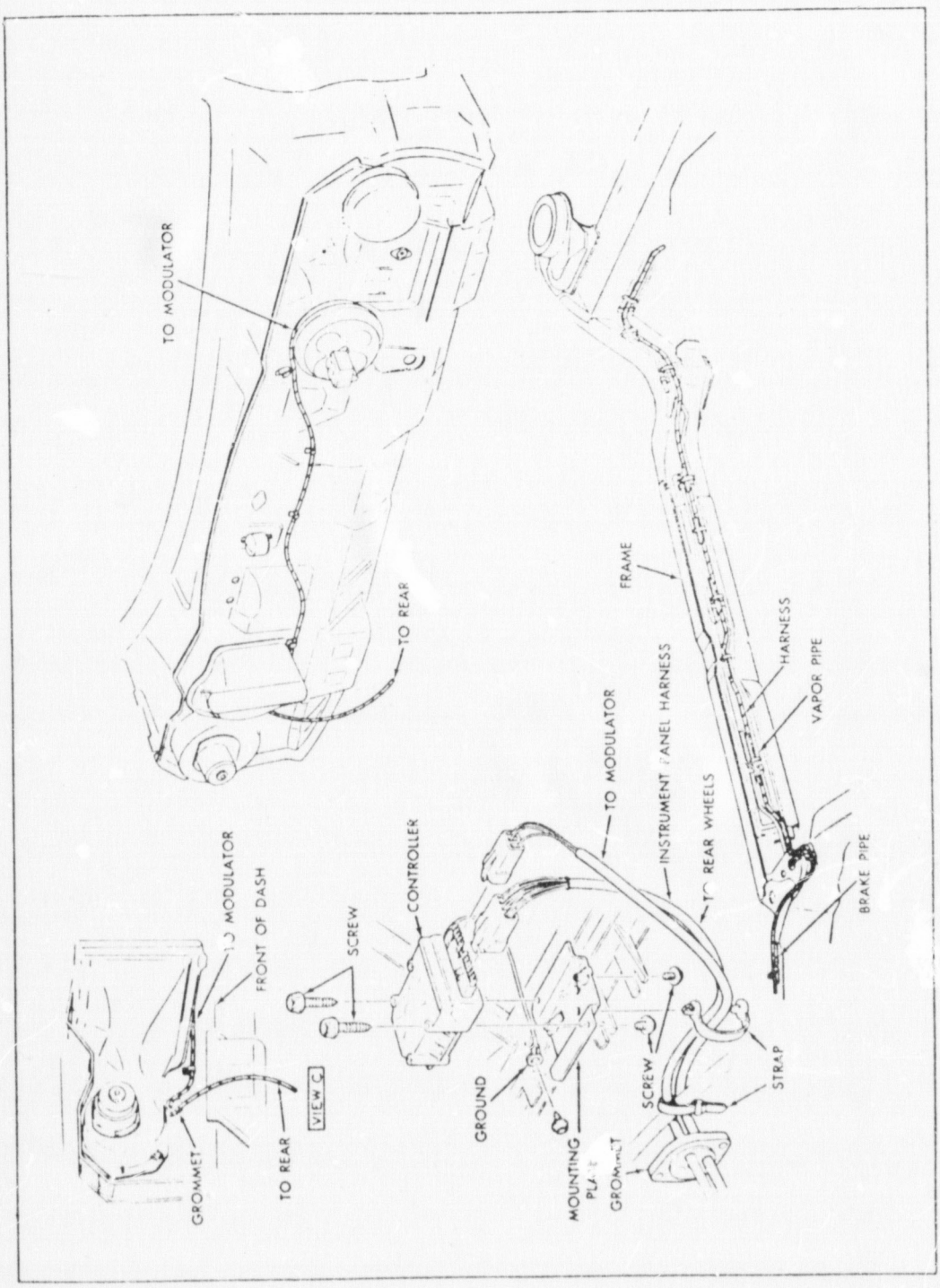



Fig. 5-86 Track Master-2

## SPECIAL TOOLS

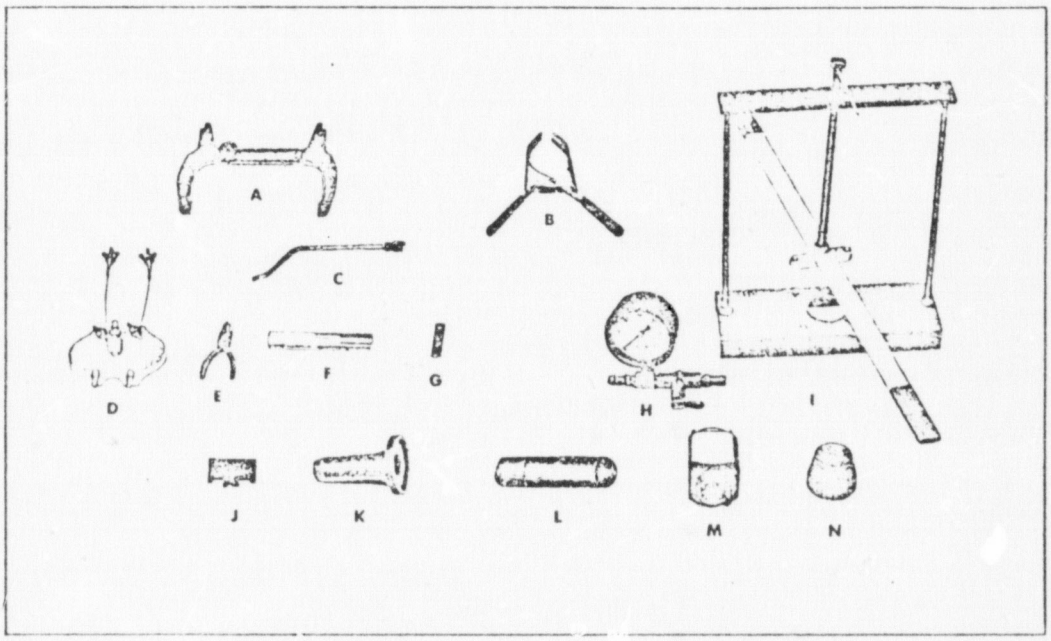
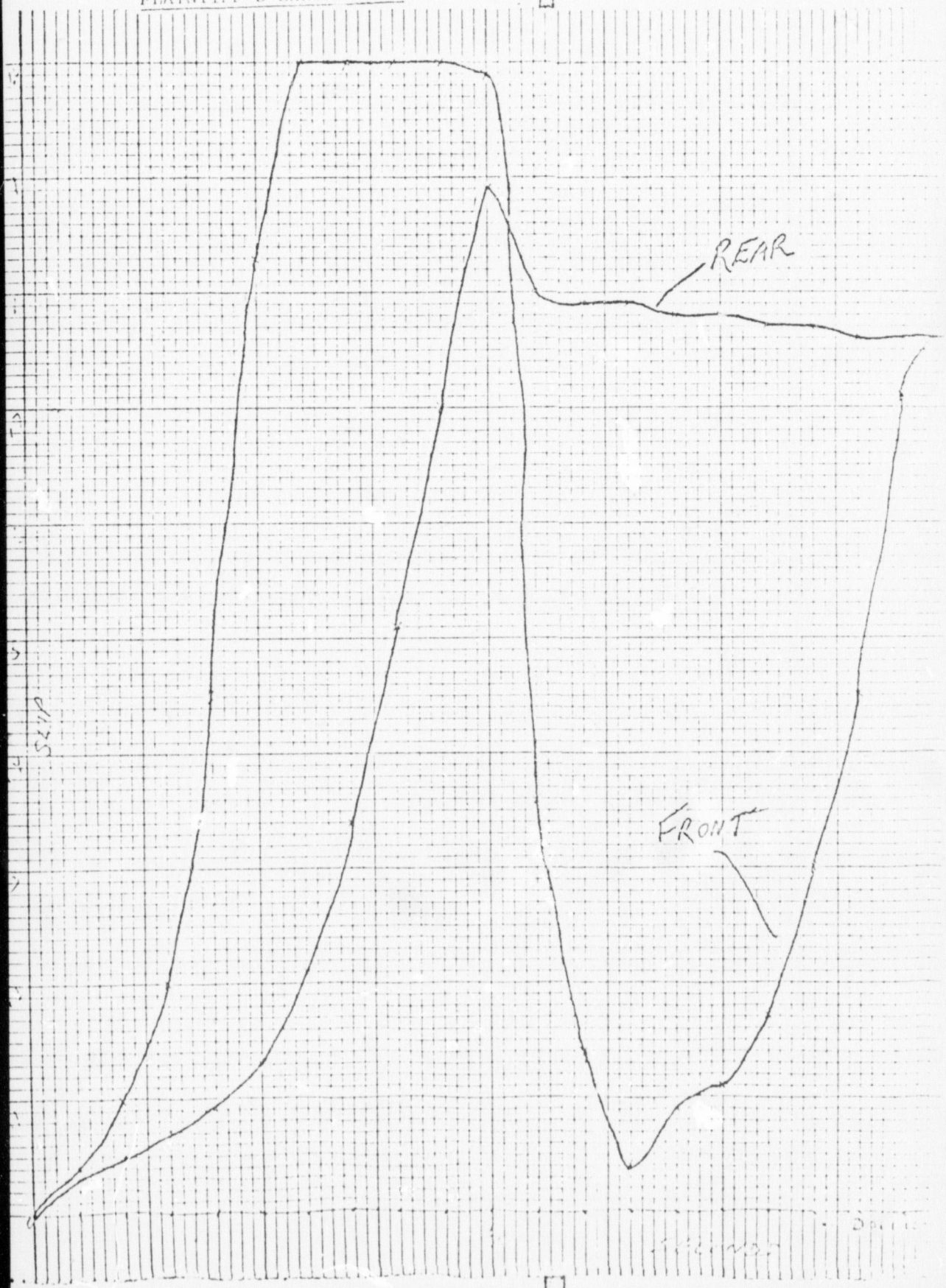
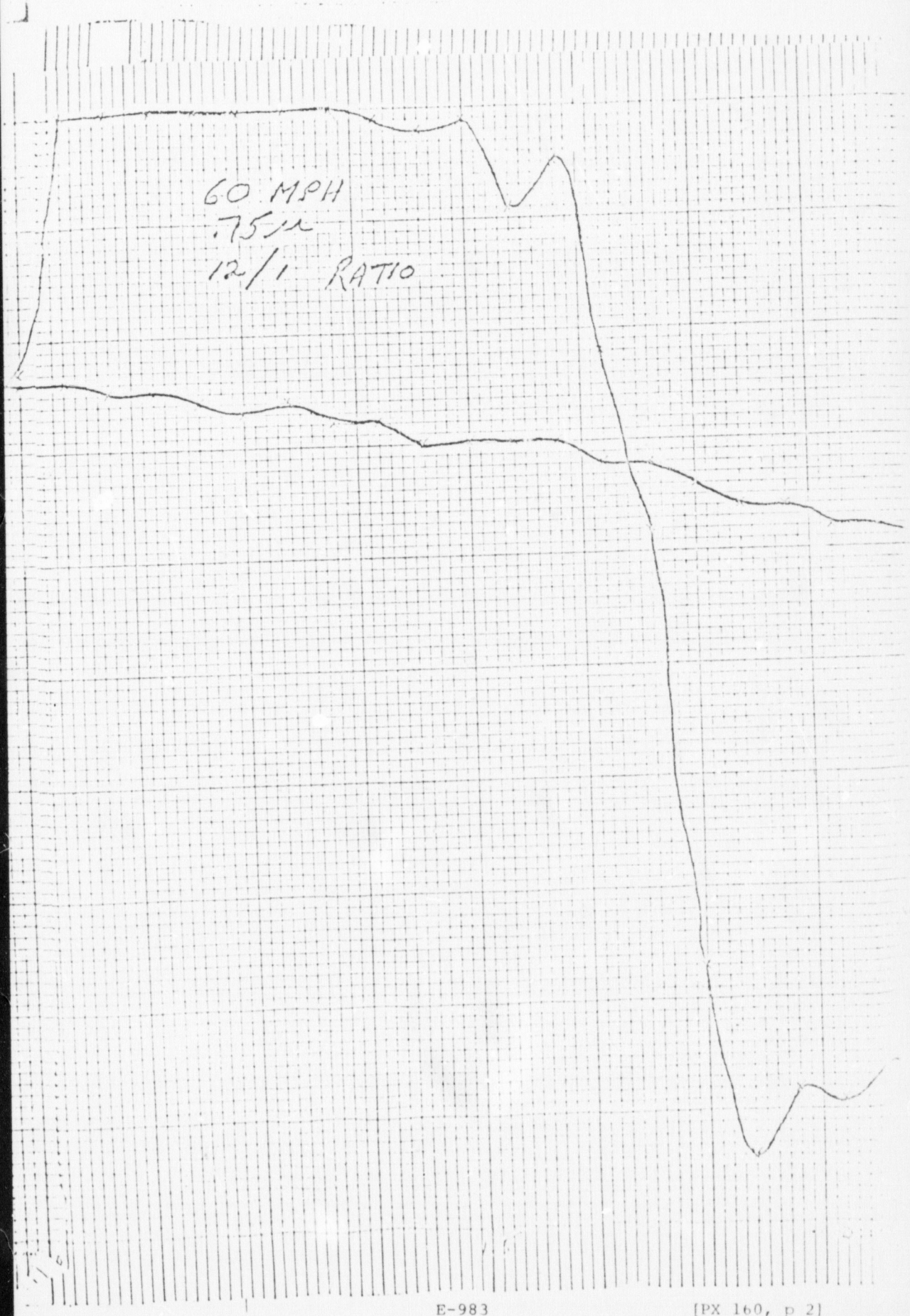


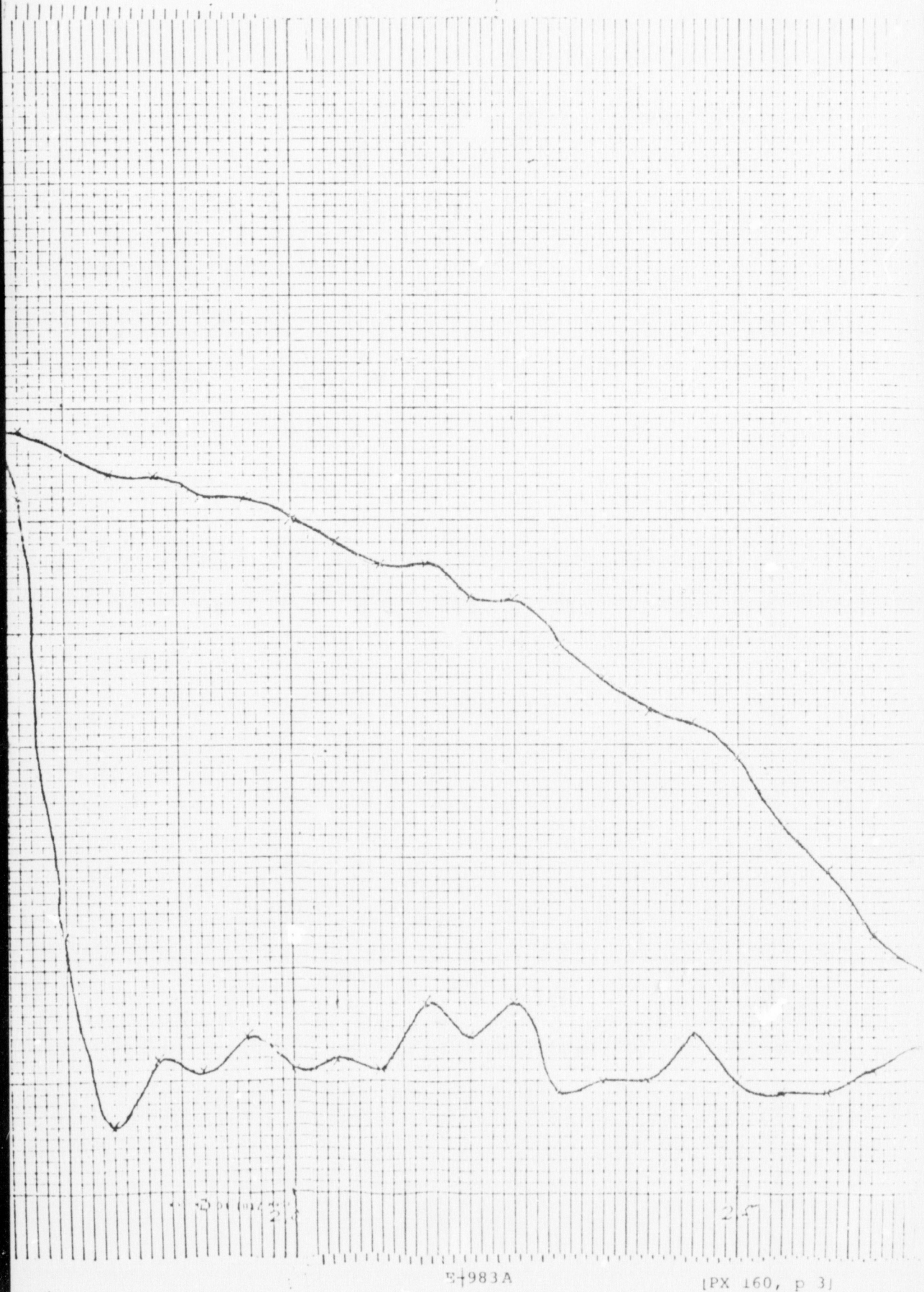

Fig. 5-87 Special Tools

| Key | Tool No. | Name | Key | Tool No. | Name |
|---|---|---|---|---|---|
| A | J-21177 | Brake Adjusting Caliper | H | J-23108 | Leak Testing Adapter |
| B | J- | Brake Combination Valve Bleeder | I | J-22884 | Power Unit Holding and Separating Fixture |
| C | J-8049 | Brake Spring Remover and Installer | J | J-22647 | Push Rod Gage |
| D | J-22489-1 | Brake Bleeder Adapter | K | J-22904 | Boot Installer |
| | J-22484-12 | Bleeder Adapter Cover Cables | L | J-23175 | Control Valve Retainer Installer |
| E | J-4880 | Snap Ring Pliers | M | J-23101 | Power Piston Holding Fixture |
| F | J-21601 | Control Valve Installer | N | J-23188 | Seal Protector |

PLAINTIFF'S EXHIBIT 160



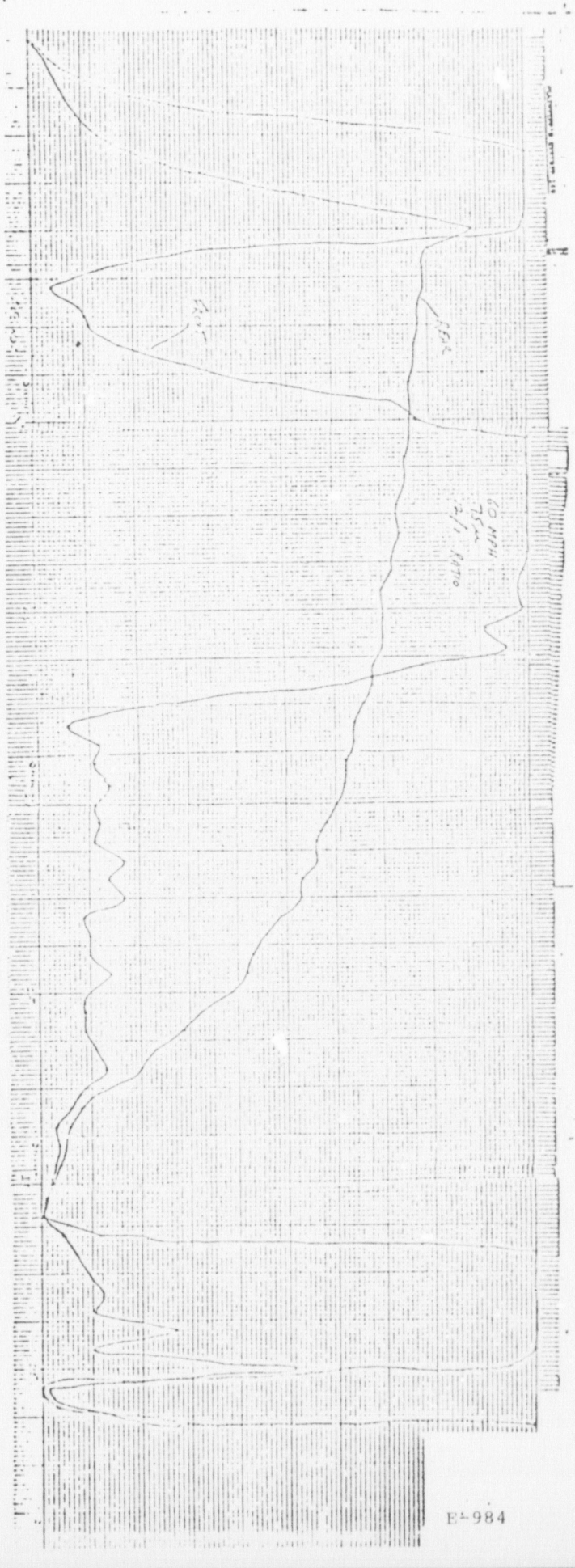

60 MPH
.75 μ
12/1 RATIO



E-983B

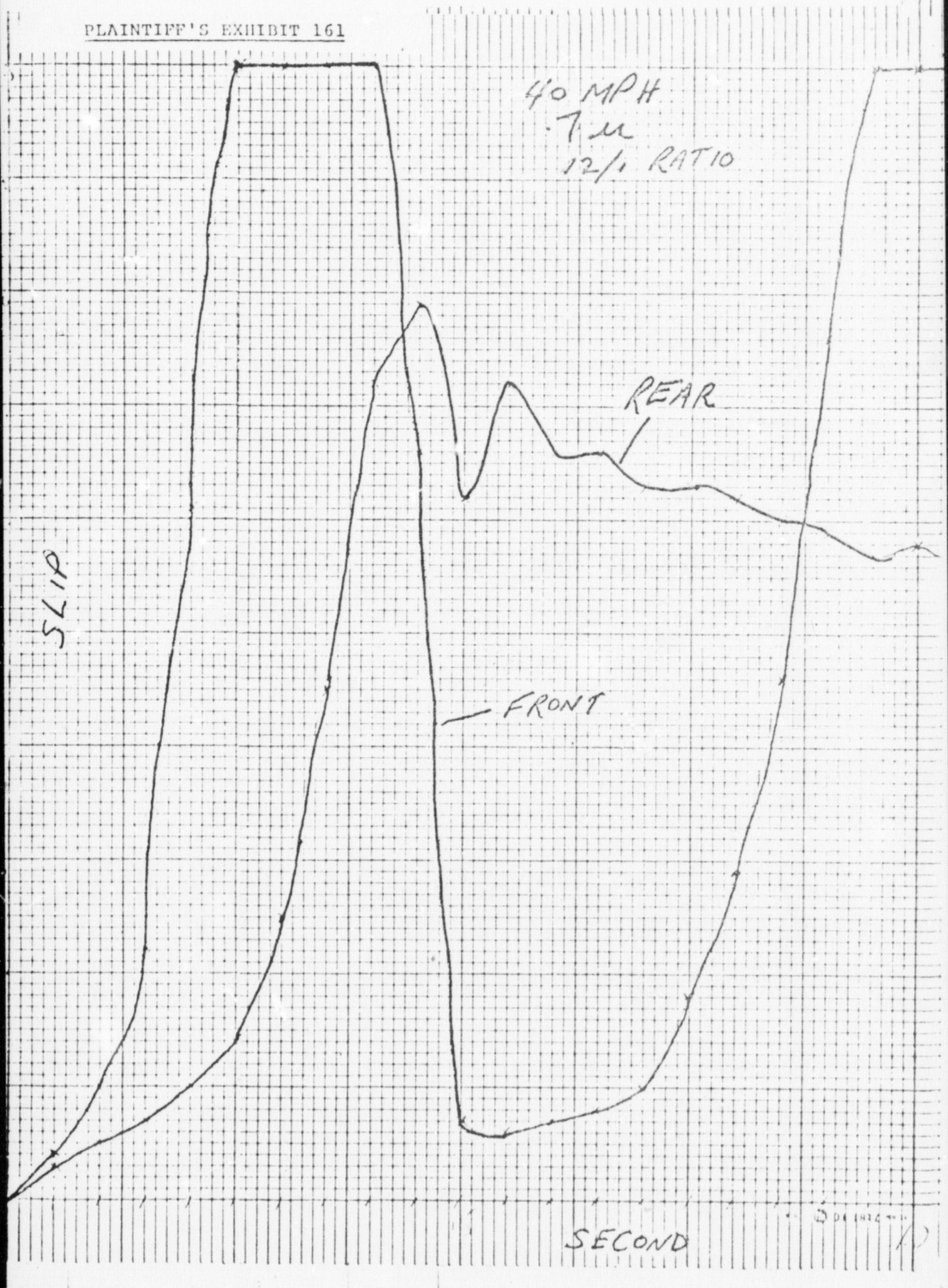
[PX 160, p 4]

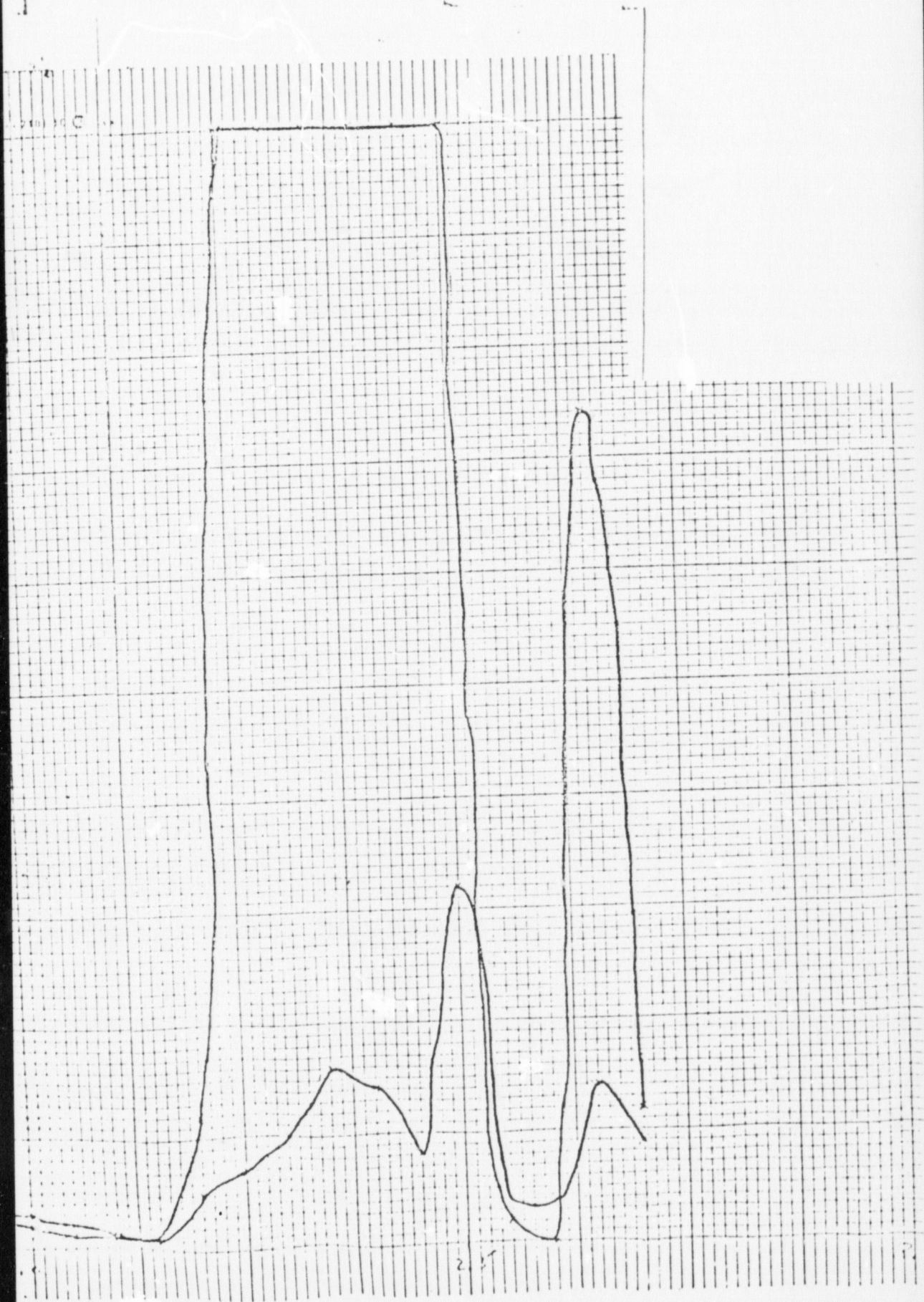
PLAINTIFF'S EXHIBIT 160
COMPLETE GRAPH (REDUCED)



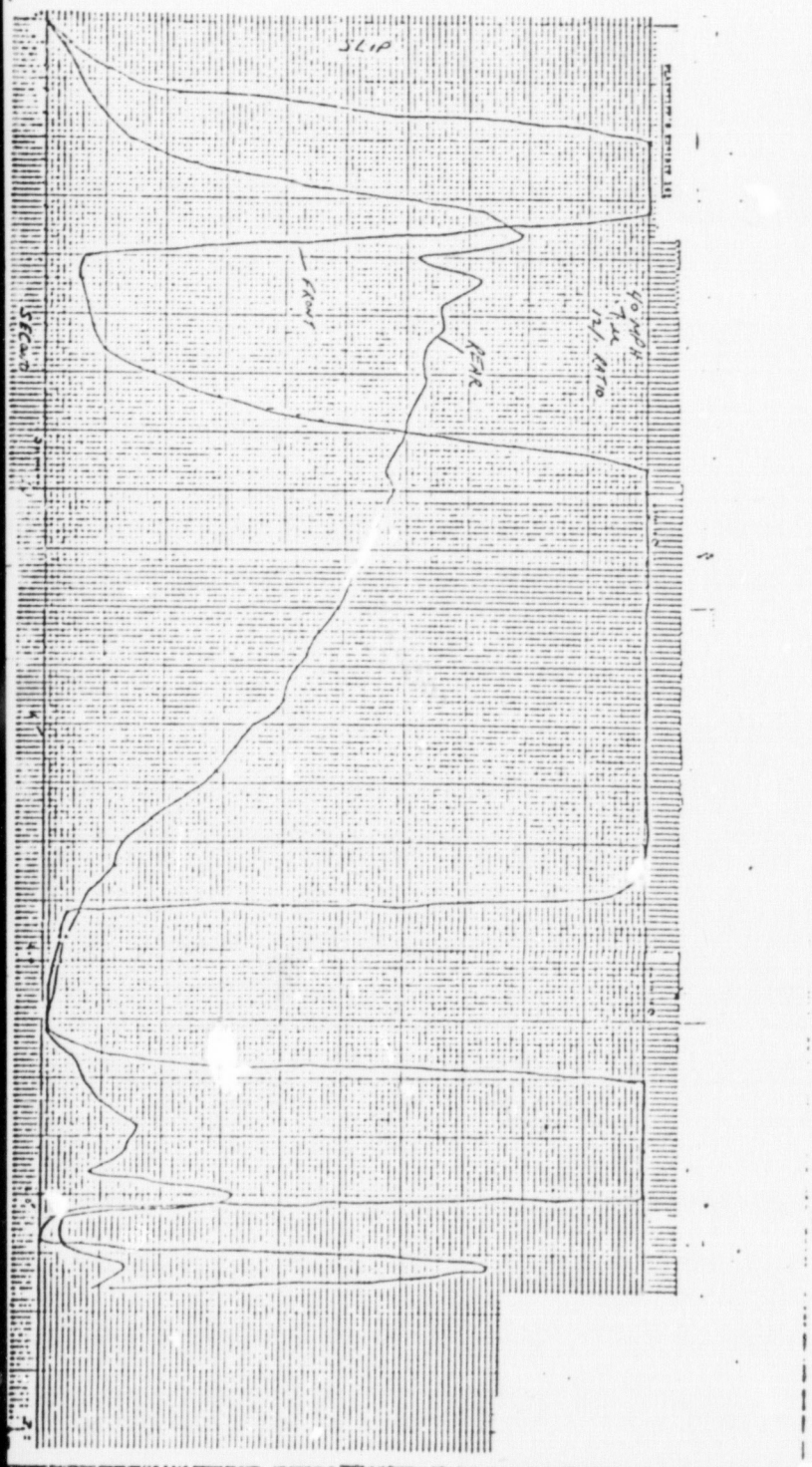


[PX 160, p 6]


PLAINTIFF'S EXHIBIT 161
40 MPH
.7 μ
12/1 RATIO
REAR
FRONT
SLIP
SECOND



PLAINTIFF'S EXHIBIT 161
COMPLETE GRAPH (REDUCED)



PLAINTIFF'S EXHIBIT 163

# 1969
# NEW MODEL TRAINING

# BRAKE SYSTEMS
# WORKBOOK

| | No. |
|---|---|
| Answer Sheet | - B - |
| Lab Session | |
| BR-I Brake Systems | BR-1 |
| BR-II Brake Skid Control System | BR-4 |
| Program Highlights | BR-20 |
| Course Objectives | BR-24 |

## BRAKE SYSTEMS

## ANSWER SHEET

Circle the answer on this sheet that indicates the selection you feel best answers the question.

11. A B C
12. A B
13. A B C
14. A B C
15. A B C
16. A B C
17. A B C
18. A B C
19. A B C D
20. A B
21. A B
22. A B C
23. A B C D
24. A B C
25. A B C D
26. A B C
27. A B C D

## LAB SESSION BR-I

## BRAKE SYSTEMS

Objectives:

Listed below are the objectives of this lab session — a summary of the things we expect you to get out of this segment of your New Model training. If for any reason you feel that you are not learning what we expect you to learn, feel free to ask your instructor for assistance; he's here to help you.

1. You will be able to locate and identify the components of the new foot-operated parking brake for Cougar.
2. You will know the function and operation of the new cable-operated parking brake release on full-size Mercurys.
3 You will be knowledgeable as to the 1969 design changes for disc brakes and the service implications.
4. You will be able to remove the bearing cups from a unicast rotor and hub assembly, utilizing the new service tool and recommended procedures.

Exercise 1:

1. Go with your instructor to a 1969 Cougar. Observe as he points out the components of the new parking brake release.
2. Refer to the Preliminary Shop Manual as your instructor reviews the removal procedure for the brake pedal on a Cougar with a manual-shift transmission.

LAB SESSION BR-I

BRAKE SYSTEMS

3. Circle the letter preceding the correct answer for the following questions:

A. The 1969 Cougar foot-operated parking brake is attached to:

(a) the cowl side panel

(b) the dash panel

(c) the floor pan

(d) none of the above

B. The Cougar foot-operated parking brake release is operated by a:

(a) button on the instrument panel

(b) vacuum-operated motor

(c) foot-operated release lever

(d) rod with a handle that is located under the instrument panel

C. Which of the following steps is NOT necessary when removing the brake pedal from the 1969 Cougar equipped with a manual-shift transmission?

(a) remove the steering column

(b) remove the clutch and brake linkages

(c) remove the master cylinder

(d) remove the brake pedal support bracket

D. Because of clutch assist spring tension, you should:

(a) remove the assist spring first

(b) hold the clutch pedal in place with a wire or small C-clamp

(c) depress the clutch pedal to remove the spring tension

(d) none of the above

## BRAKE SYSTEMS

Exercise 2:

1. Go with your instructor to the Mercury school car. Observe as he discusses the function and operation of the new cable-operated parking brake release.
2. On the bench, remove the bearing cup from the unicast rotor and hub assembly from the disassembled disc brake assembly, utilizing the special service tool provided for this operation.
3. When you have completed the work at the bench, answer the following questions:

   A. The purpose of the shorter inboard brake shoe is to:

      (a) reduce the cost of the part

      (b) provide more room for expansion between the anchor plate bosses.

      (c) both of the above

      (d) neither of the above

   B. The increased length of the outboard brake lining will:

      (a) give longer lining life

      (b) give better braking performance

      (c) both of the above

      (d) neither of the above

   C. The more effectively vented splash shield will:

      (a) force air onto the rotor

      (b) provide better cooling

      (c) both of the above

      (d) neither of the above

## [illegible] SKID CONTROL SYSTEM

Objectives:

1. You will be able to locate and identify the major components of the brake skid control system.
2. You will know the purpose and function of each major component of the brake skid control system, and how these components operate as a system.
3. You will be able to determine whether the trouble is in the hydraulic system or in the skid control system when a brake system malfunction is indicated by the illuminated warning light on the instrument panel.

Exercise 1:

1. Your instructor will conduct a lecture-discussion period to familiarize you with the function of the brake skid control system and its individual components (Figure 1).

   Note: Refer to Figure 2.

   On vehicles equipped with brake skid control systems, when a brake system malfunction is indicated by the brake warning light being illuminated on the instrument panel, it is necessary to determine whether the trouble area is in the brake hydraulic system or in the skid control system. This can be determined by disconnecting the switch plug from the pressure differential valve assembly. If the warning light is extinguished when the switch wire harness plug connector is disconnected, the malfunction is in the brake hydraulic system. To check the hydraulic system, follow the procedure outlined in the 1969 Shop Manual. If the brake warning light continues to burn after the pressure differential switch wire has been disconnected, the trouble is in the skid control system.

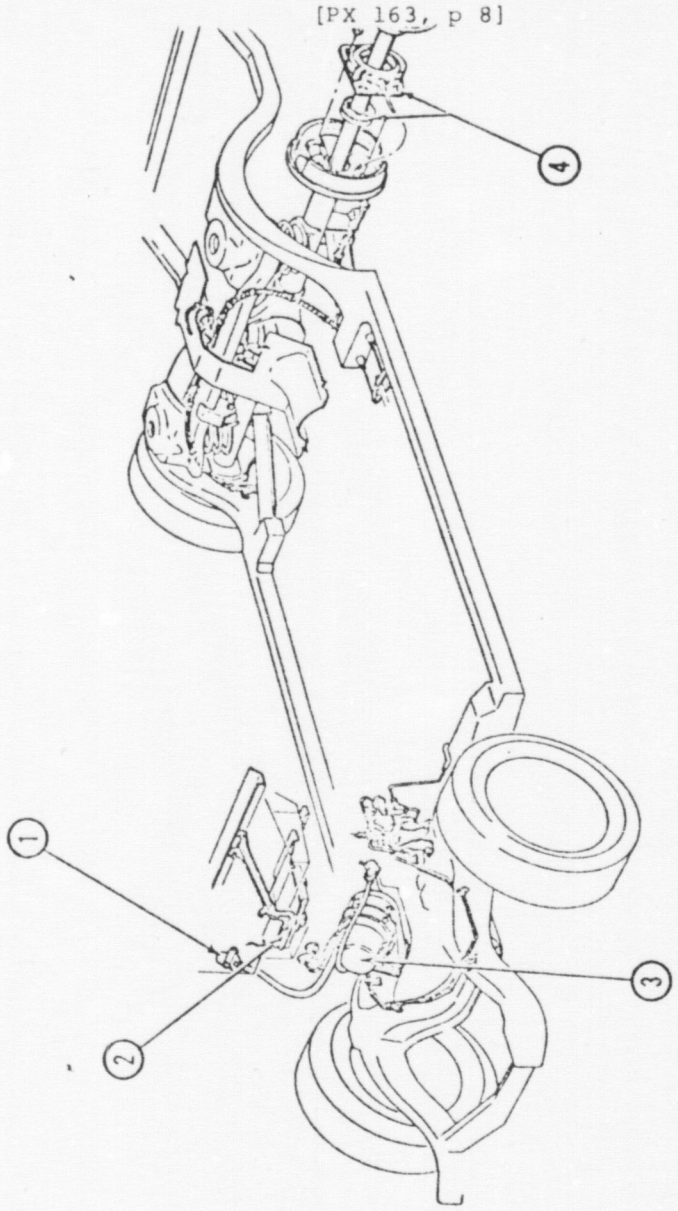



Figure 1 — Brake Skid Control System

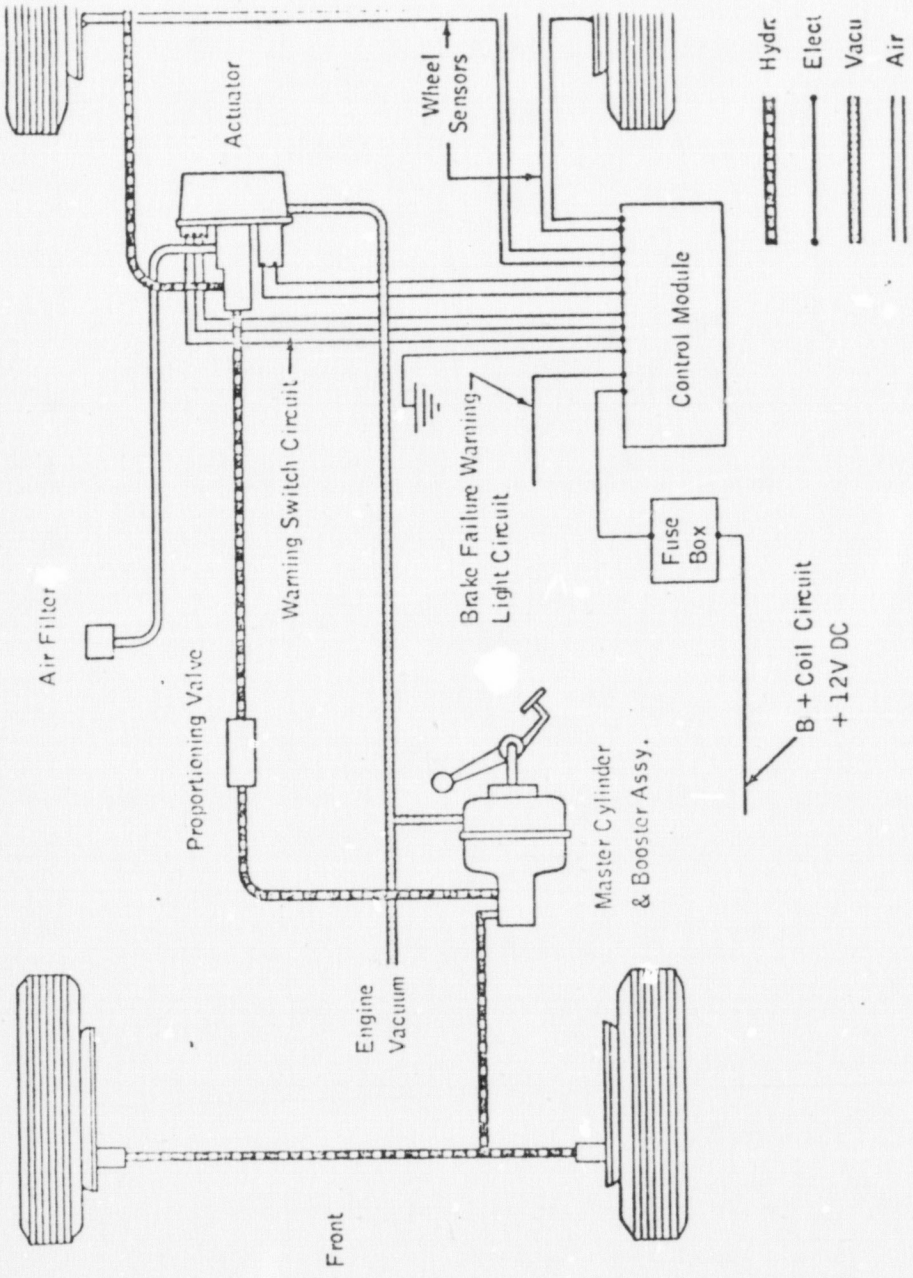



Figure 2 — Brake Skid Control Schematic

Service Procedures

The service approach to the skid control system will consist of replacing complete component assemblies, and sending the malfunctioning assemblies to Dearborn. No repair or adjustments to components will be done in the field.

The test equipment and diagnostic procedures that will be used to trouble-shoot the skid control system have not been finalized to this date. This information will be released as soon as it is available.

2. When the lecture-discussion period has been completed, answer the following questions by circling the letter preceding the correct answer:

A. In the illustration (Fig. I), part number 3 is the:

(a) brake booster assembly

(b) modulator

(c) rotor and stator assembly

(d) actuator

B. The brake skid control system functions from:

(a) 5 to 80 MPH

(b) 14 to 63 MPH

(c) 25 to 90 MPH

(d) at all speeds

C. If the warning light goes out when the switch plug is disconnected from the pressure differential valve assembly, the malfunction will be found in the:

(a) skid control system

(b) brake hydraulic system

(c) wheel sensors

(d) none of the above

Reference Information:

The following information is provided for you as reference information after the school. It is a recap of what you heard and saw in the audio-visual presentation.

The sensor consists of a rotor and stator assembly. The rotor is a steel ring that's pressed on the outside axle shaft, just outboard of the wheel bearing. The teeth on the outside diameter of the rotor rotate past corresponding teeth on the inside diameter of the stator, which is a stationary steel ring. Refer to Figure 3.

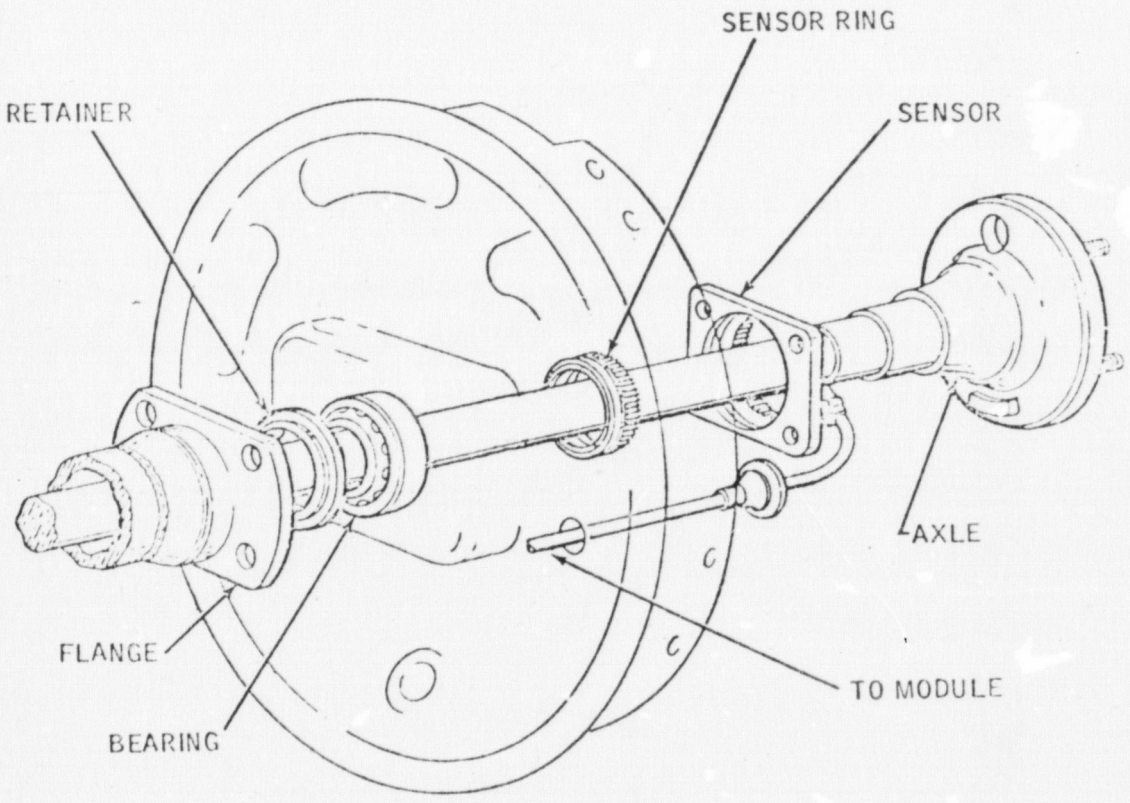



Figure 3 — Brake Skid Control Axle Shaft

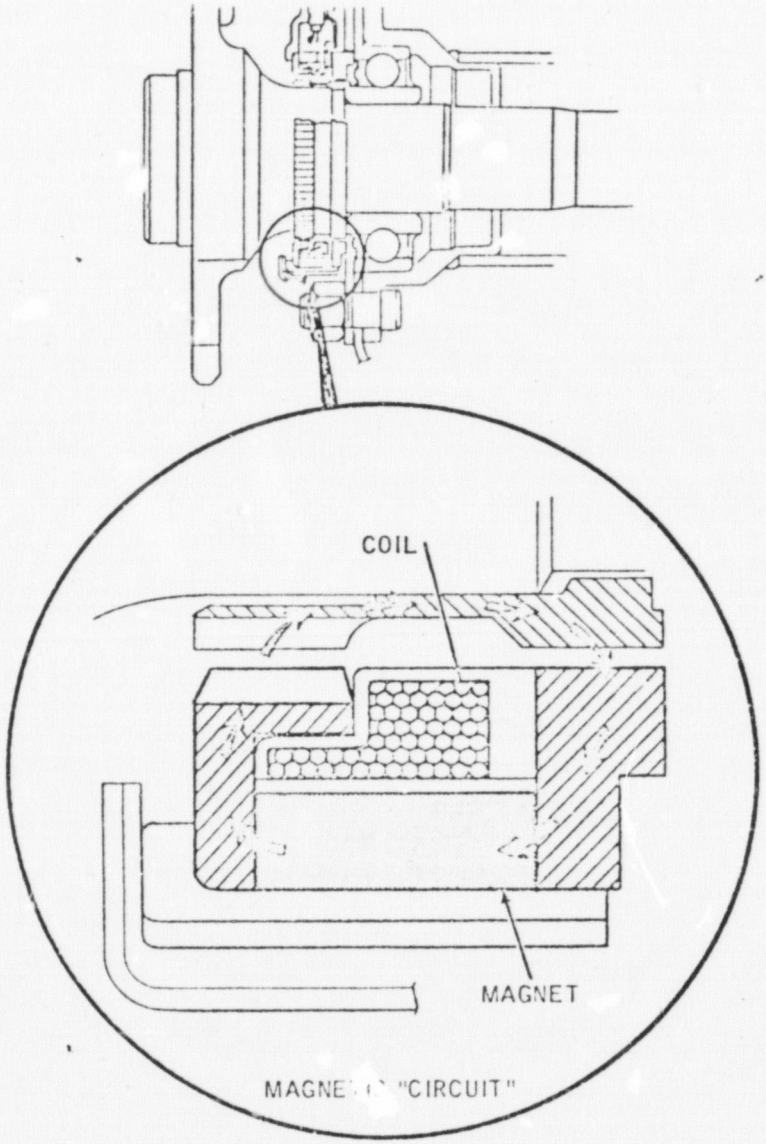



Figure 4 — Brake Skid Control Sensor

The stator assembly also contains ring-shaped permanent magnets and coils of wire. The whole assembly bolts to the brake backing plate.

The axle turns and the teeth on the rotor move past the teeth on the stator. When the rear wheels reach a speed of about 5 mph, the field around the magnet fluctuates and this sets up an electric current in the coil. AC voltage pulses are generated in proportion to the speed of the rear wheels. These pulses are transmitted from the sensor by wires to the control module. Refer to Figure 4.

Notice that there are five plug sockets on the module. These are the leads to the actuator, sensors and power source. The individual connectors are shaped to fit only one socket. Do not attempt to force a connector into the wrong socket.

It's here that the module receives information in the form of current and continuously monitors rear wheel speed. It operates on the sum of the signals from both rear wheels. When the sum of the signals drops below a pre-determined level due to deceleration, the module sends a message to the actuator solenoid and commands it to release the brakes. Then, when the wheel acceleration again increases, the modulator shuts off the signal and de-energizes the solenoid, allowing the brakes to reapply. This cycle of events continues to occur until the skid is corrected or the vehicle speed drops to about 4 mph.

There is a fail-safe feature built into the module which calls for a continuous sequence of events to occur. Should one of the events fail to occur, the modulator will take the skid control out of the system. Also, there is a time delay switch mounted on the actuator which will take the rear brakes out of the system should a lock-up of more than 60 seconds occur. In either case, the module will send a signal to the brake warning light. Refer to Figure 5.

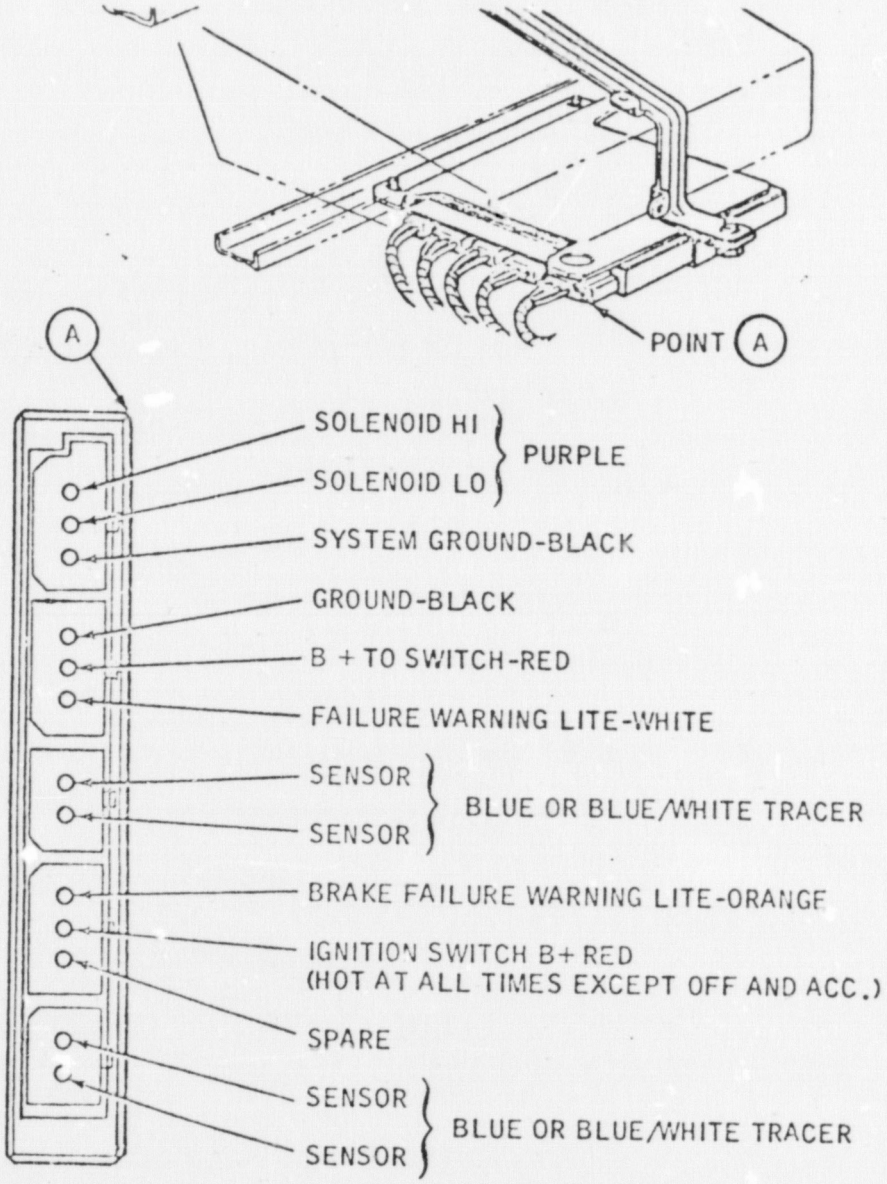



Figure 5 — Brake Skid Control Module

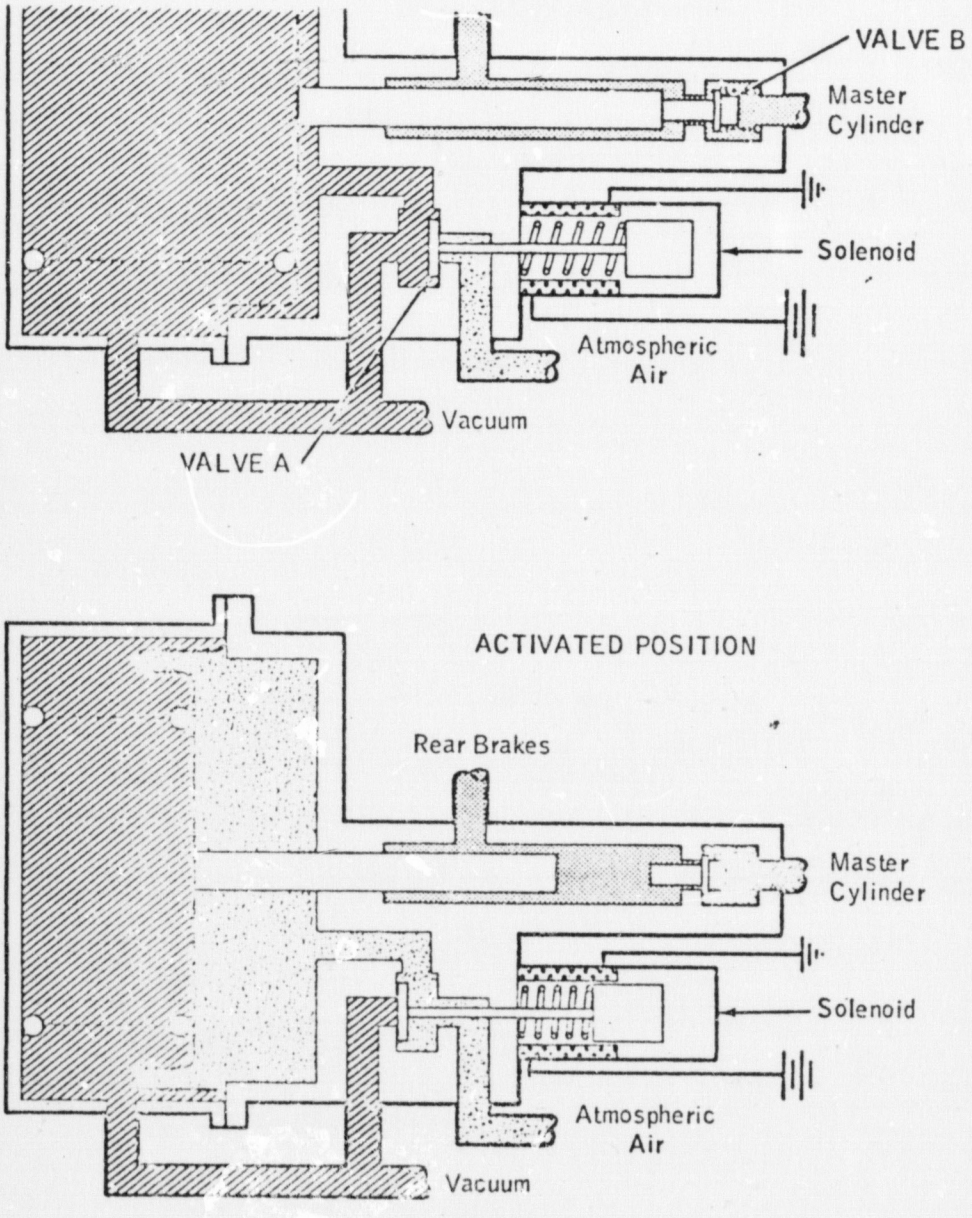



Figure 3 — Brake Skid Control Actuator

The actuator is similar to a brake booster. It has three major parts; a vacuum chamber, a brake pressure chamber and a solenoid. These components function together to release and reapply the rear brakes upon command from the module.

Let's look at the normal position of the actuator, that is, when the skid control is not operating. The solenoid is not energized, therefore, the solenoid valve spring holds the solenoid valve against the air passage port and prevents air from entering the vacuum chamber. Refer to Figure 6.

Notice that the vacuum chamber contains a diaphragm with a spring mounted against it. The vacuum chamber is divided into two parts. The front side of the diaphragm draws vacuum directly from the engine intake manifold vacuum fitting. From here, vacuum goes past the solenoid valve to the rear side of the diaphragm. The spring holds the diaphragm rearward. The front and rear brakes operate normally when the actuator is in the normal position.

Now let's look at the actuator in the activated position, that is, when the control module commands the brake skid control system to go to work. Refer to Figure 6.

The control module sends its signal to the solenoid and the energized solenoid moves the valve to close the vacuum passage. Now, no vacuum reaches the rear side of the diaphragm. It is opened to atmospheric air through an air filter on the hood hinge support. The engine keeps drawing vacuum to the front side of the diaphragm,

BRAKE SKID CONTROL SYSTEM

therefore there's a difference in pressure on the two sides of the diaphragm. This pressure differential overcomes the spring and forces the diaphragm forward and of course, the piston rod moves forward with it to close the brake chamber valve. Then, the volume of the pressure chamber grows, decreasing the rear brake line pressure which in turn releases the rear brakes. With the actuator in the activated position the rear brakes are isolated from the rest of the system.

As the rear wheels spin up, the control module releases the signal to the solenoid and the solenoid valve returns to its original position. Vacuum is again drawn behind the diaphragm and the spring returns the diaphragm rearward. The piston moves back into the pressure chamber, opening the brake chamber valve, thus reapplying rear brake pressure.

The actuator continues this cycle up to four times per second until the vehicle speed drops to about four miles per hour.

It is possible that the skid control system may never be used even if it is installed on a car. But even if its used a few times during the life of the car, it must be in good working order when it's needed. To keep it in working order, a circuit is provided from the ignition switch to the control module so that every time the ignition switch is turned on, the control module commands the actuator to go through one cycle. This one cycle lubricates the hydraulic seals and prevents potential leaks.

The following component replacement procedures are provided as preliminary information to familiarize you with the complexity of servicing the skid control system. This is not final information and is subject to change.

Brake Skid Control Actuator

Removal

1. Working in the passenger compartment, under the glove box, remove the screw that attaches the forward end of the control module retainer to the support assembly. Lower the forward end of the control module retainer and remove the module assembly.
2. Disconnect the actuator solenoid and warning switch harness connectors from the control module.
3. Remove the two wiring harness grommets from the dash panel and push the wiring harness and connectors through the openings in the dash panel.
4. Working in the engine compartment, loosen the hose clamp and remove the air hose from the air filter.
5. Remove the engine air cleaner. Loosen the hose clamp and remove the vacuum hose from the vacuum manifold fitting.
6. Raise the vehicle on a hoist.
7. Disconnect the exhaust pipes from the exhaust manifold and support with wire to provide access to the actuator assembly.
8. Remove the bolt retaining the actuator ground wire at the rear outer corner of the engine right bank.
9. Loosen the tube nuts and disconnect the brake system hydraulic tubes from the hydraulic valve housing.

10. Remove the three nuts retaining the actuator assembly to the actuator support bracket.
11. Remove the three bolts that retain the actuator mounting bracket to the side rail and remove the mounting bracket.
12. Remove the actuator assembly from the vehicle and place it on a bench.
13. Remove the air and vacuum hoses from the actuator.

Installation

1. Install the air and vacuum hoses on the new actuator.
2. Place the actuator assembly into position under the vehicle, routing the air and vacuum hoses up between the engine and fender apron and inserting the solenoid leads through the holes in the dash panel.
3. Position the ground wire to the rear of the engine block and install the retaining bolt.
4. Position the actuator mounting bracket to the frame side rail and install the three retaining bolts.
5. Position the actuator assembly to the mounting bracket and install the three retaining nuts.
6. Connect the hydraulic tubes to the hydraulic valve assembly and tighten the tube nuts to 8-15 ft-lbs torque.
7. Connect the exhaust pipes to the exhaust manifolds.
8. Lower the vehicle.
9. Pull the actuator solenoid and brake warning switch wiring harness through the two holes in the dash panel from inside the car. Seat the wiring harness grommets in the dash panel.

LAB SESSION BR-II

BRAKE SKID CONTROL SYSTEM

10. Connect the actuator solenoid and brake warning switch wiring harness connectors to the control modules.
11. Position the control module in the bracket under the glove box and install the retaining screw.
12. In the engine compartment, connect the air hose to the air filter and position the hose clamp.
13. Connect the vacuum hose to the engine vacuum manifold fitting. Install the engine air cleaner.
14. Bleed the rear brake system and centralize the pressure differential valve.
15. Raise the rear wheels. Apply the brakes with the rear wheels turning to verify proper operation of the skid control system.

Brake Skid Control Module

Removal

1. Remove the panduit strap holding the harnesses.
2. Remove the screw that attaches the forward end of the control module retainer to the support assembly.
3. Lower the forward end of the control module and retainer from the support assembly; move the module and retainer forward slightly until the flange clears the slot in the support assembly.
4. Disconnect the five wiring harness plugs from the control module.
5. Remove the control module from the vehicle.

Installation

1. Connect the five wiring harness plugs to the control module. Only one arrangement is possible.

2. Position the control module in the retainer, orienting the module per the markings on it, and insert the retainer flange into the slot at the rear of the support assembly.
3. Pivot the retainer and control module upward and align the screw hole in the forward end of the retainer with the hole in the support bracket assembly. Install the retaining screw.
4. Test the vehicle on the hoist to verify correct operation of the skid control system.
5. Panduit strap the wiring to the module support extension.

Brake Skid Control Sensor

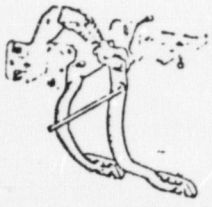
Removal

1. Raise the vehicle on a hoist.
2. Remove the rear wheel and tire assembly.
3. Remove the three Tinnerman nuts and remove the brake drum.
4. Disconnect the sensor lead from the rear wiring harness.
5. Unseat the sensor lead grommet, pushing it to the inside of the brake assembly.
6. Remove the four nuts that retain the sensor to the backing plate and pull the axle shaft, sensor assembly and wheel bearing assembly from the axle housing.
7. Press the wheel bearing retainer and wheel bearing off the axle shaft.
8. Remove the sensor assembly and press the rotor off the shaft.

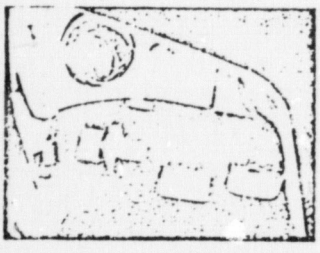
Installation

1. Press a new rotor onto the axle shaft. Install a new sensor assembly on the shaft, and press the bearing and bearing retainer onto the shaft.

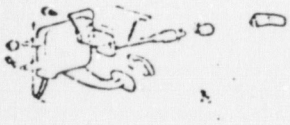
2. Insert the axle shaft assembly in the rear axle housing onto the four backing plate retaining bolts, feeding the sensor lead through the hole in the backing plate.
3. Seat the sensor lead grommet in the backing plate.
4. Install the four nuts on the retaining bolts and tighten to 50-75 ft-lbs torque.
5. Connect the sensor lead to the rear wiring harness and install two panduit straps.
6. Install the rear brake drum and retain with the Tinnerman drum retaining nuts.
7. Install the rear wheel and tire assembly and tighten the wheel nuts to 70-115 ft-lbs torque.
8. Test the vehicle on the hoist to verify proper operation of the skid control system.



A new feature for the 1969 Cougar is the revised brake pedal support. To remove the brake pedal on a Cougar with manual-shift transmission, you must remove the steering column, disconnect the clutch pedal and brake pedal linkage, and remove the brake pedal support from the vehicle.



Cougar also has a new foot-operated parking brake.



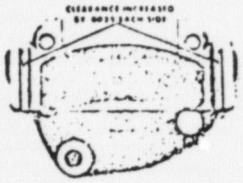
There's a new cable-operated brake release on all full-size Mercurys.

In 1969, the 11-inch diameter linkless brake booster will be installed in the Mark III. This booster is the single diaphragm type and service procedures are the same as for other brake boosters.

Disc brakes on full-size vehicles will incorporate a unicast rotor and hub assembly.

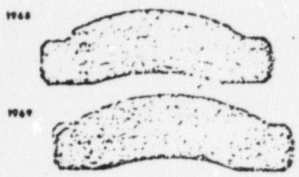
There's a new bearing cup removal tool (T69L-1102-A) released for this service operation.

INBOARD SHOE FIT TO ANCHOR PLATE
1968 VS 1969

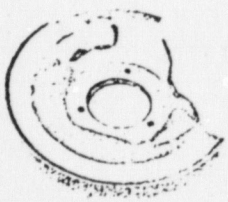


Disc brakes will also have redesigned linings in 1969. Inboard shoes will be slightly shorter providing more room for expansion between the anchor plate bosses.

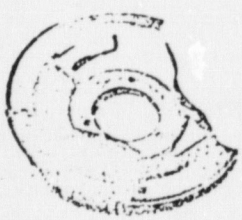
OUTBOARD SHOE AND LINING ASSEMBLY
1968 VS 1969




The outboard linings will be considerably longer. This means better performance and longer lining life.

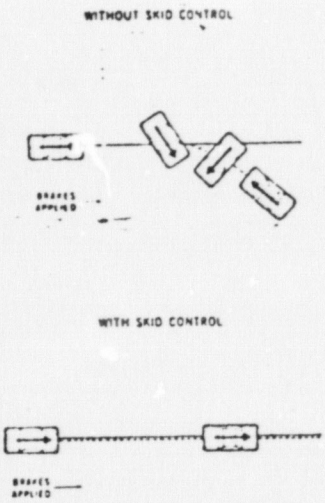


Disc brake splash shields are vented more effectively in 1969. The vents force air onto the rotor and thus provide better cooling. The vents on full-size vehicles will be stamped into the splash shield.



Police units will utilize two-piece vented splash shields. The vents are welded to the splash shield and are considerably larger.

The system consists of three major components; wheel sensors, control module, and a vacuum-powered actuator.




The new skid control braking system helps the driver avoid the kind of skid shown, which may occur occur during braking on slippery road surfaces or in extreme panic stops. A paperback-book-sized computer, mounted beneath the glove compartment, provides the "brain" for the skid control system which helps keep the car going straight in such situations.

BR-23

E-1015

Systems. We hope we've met our goals.

1. You will know that it is necessary to remove the steering column, disconnect the clutch pedal and brake pedal linkages and remove the brake pedal support to remove a brake pedal from a 1969 Cougar with manual-shift transmission.

2. You will be able to locate and identify the components of the new foot-operated parking brake for Cougar.

3. You will know the function and operation of the new cable-operated parking brake release on full-size Mercurys.

4. You will be knowledgeable as to the 1969 design changes for disc brakes and the service implications.

5. You will be able to remove the bearing cups from a unicast rotor and hub assembly, utilizing the new service tool and recommended procedures.

6. You will be able to locate and identify the major components of the brake skid control system.

7. You will know the purpose and function of each major component of the brake skid control system, and how these components operate as a system.

8. You will be able to determine whether the trouble is in the hydraulic system or in the skid control system when a brake system malfunction is indicated by the illuminated warning light on the instrument panel.

DEFENDANT'S EXHIBITS RECEIVED IN EVIDENCE AT TRIAL

DEFENDANT'S EXHIBIT 1
SOUNDTRACK OF PERMA FILM
(TRANSCRIBED DURING THE DEPOSITION OF ROBERT PATTEN 11/14/73

("SOUND TRACK OF FILM

"You are about to see an accident. It could be a costly accident. In this case, it was only a wrinkled fender.

"The files of law enforcement agencies are filled with photos of accidents that could have been avoided. Many of these accidents were caused by panic and uncontrolled skids.

COMMERCE REPORTING CO.
150 NASSAU STREET, NEW YORK, N.Y. 10038 • WOrth 4-3567

At a recent highway safety seminar, a prominent safety official said:

"'Skids play an important role in causing the accident rate to be higher than necessary. Highway accidents may be cut 25 per cent when anti-skid devices are installed on all automobiles.'

"Records show that nearly 1 out of 4 accidents on the Pennsylvania Turnpike in 1962 and 1963 involve the failure of the driver to cope with a skidding situation. Every day, the newspapers tell of auto accidents due to skidding. Automobile accident rates throughout the country are increasing. Although highway designers and builders are constructing new, wide freeways in an effort to reduce this appalling accident rate, the basic cause of accidents remains.

"Ice and snow during the winter months make driving hazardous and dangerous at best. But other road conditions can be as hazardous.

"This modern asphalt six-lane highway during the first 30 minutes of a rainstorm becomes slick and treacherous. The black oil drippings from trucks and cars down the center of each lane is a ribbon of death when wet. Wet leaves

on the highway during fall can produce slipping, sliding and skidding. In late fall, a wet highway is beginning to freeze, creates an instantaneous ice condition which always produces a rash of accidents. Loose gravel on rural roads can even cause skidding in panic situations. Fast panic stops on dry roads often result in uncontrolled skids.

"For years the skidding problem has been getting worse. Cars have been increasing in size with larger engines and more power, and to go with this increase, power brakes have been introduced, thus increasing the tendency to skid under panic conditions. There is no way to speed up the driver's reaction time.

"So the accidental skidding of cars continued until Frank Perrino of North Attleboro, Mass. invented the Perma Anti-Skid Control.

"This remarkable unit is the result of five years of testing and research by Mr. Perrino AND his engineering staff of Perma Research & Development Co.

"The Perm Anti-Skid Control is the first practical approach to solving the skid problem and

Perma Research is the first to introduce an anti-skid control commercially available to the general public.

"Here's how it works: The physics of stopping a car are quite simple. When the brakes are applied the friction of the tire against the road slows and stops the car. In a panic condition the brake is usually applied to maximum pressure, thus causing the wheel to lock. On slick roadways such as ice and snow this locking of the wheel occurs with only a small amount of pressure on the brake.

"With dry pavement more pressure is needed. Most drivers are taught to pump the brake, thereby keeping the steering control over the car. But in a panic condition even experienced drivers forget this principle and jam on the brakes and the car begins to skid. The locked front wheels has no steering value and the locked rear wheels track badly.

"The principle of the Perma Anti-Skid Control is to automatically sense the split-second locking of the wheels, release them, then reapply the brakes. This on-and-off braking cycle

provides the quickest possible stopping on any given road surface, yet allows steering control, thus preventing uncontrolled skids.

"This slow-motion movie shows this cycle action of the wheel. This cycle action will also sense intermittent road conditions such as ice to dry pavement and back to ice and snow.

"Split road conditions of ice on one side and dry on the other are compensated for automatically. There is no need to pump the Perma Anti-Skid Control. Just push it down all the way and hold it. It works -- automatically.

"It also provides protection against skidding at slow speeds under normal braking conditions. The sensing device of the Perma Anti-Skid Control is a small mechanical brain which senses the impending wheel lock.

"Inside is a rotating governor turning at ultra-high speed. Because of this high speed response characteristics, the mechanical brain reacts faster than human reaction. This high speed, invisible to the human eye, is slowed down by the slow motion camera.

"When wheel lock-up occurs, the governor

stops for a milli-second, releasing the brakes, then instantaneously revolves again, applying the brakes. Jet aircraft use the same anti-skid principle on the wheels of the landing gear costing thousands of dollars.

"With the introduction of the Perma Anti-Skid Control the safety of anti-skid protection can be purchased at a price everyone can afford.

"This low-cost unit is in the same price range as a car radio or heater. It is significant that the cost of most accidents is many times greater than the cost of a Perma-Anti-Skid Control.

"With the purchase of this unique safety device you not only protect you and your family from skidding, but you get a better brake. It will stop you faster with less tire wear as well as providing positive control action during stops on any road surface.

"Motor Vehicle Research of New Hampshire is one of the independent laboratories that has tested the Perma-Anti-Skid unit. The unit is continually subjected to gruelling tests by the

same research scientists who have contributed to the development of other significant technological advances.

"To develop the proper gears, units were operated at a constant speed of 65 miles per hour for up to 8000 miles. Dozens of [SHOULD BE FIGURE] different types of gears were tested for dependability and longevity.

"The final selection Delrin, a new self-lubricating plastic composition developed by DuPont. To verify this selection, tests continued. Here, the unit is subjected to the same punishment it would take if installed in a car that continuously sped to 80 miles per hour and came to a panic stop every 1-1/2 seconds.

"The same test sequences were carried out in temperatures of up to 300° above zero and 60° below zero.

"In all cases, well beyond the usage of any motor vehicle, the Perma Anti-Skid Control unit proved its longevity; proved its dependability; proved that it not only prevents uncontrolled skidding but stops a car in a shorter distance.

"This same dramatic proof has been

illustrated before all types of audiences including highway and safety officials, law enforcement agencies and insurance companies throughout the United States and Canada.

"The Perma Anti-Skid Control carries a full year warranty and includes a fail-safe feature which will automatically revert to the standard braking system in case of failure.

"It is recognized as THE most outstanding advancement in automotive braking safety. This recognition by safety officials has resulted in the use of Perma Anti-Skid Controls in official cars as well as the cars of the general motoring public.

"The intense interest in the Perma Anti-Skid Control has resulted in hundreds of articles in magazines and newspapers. These articles have produced an avalanche of inquiries for this remarkable new product from all over the world. The reasons are obvious. At one time or another every driver has experienced the horror of any uncontrolled skid. Any new development is eagerly viewed as a way to safe driving.

One of the reasons for the low price of

the Perma Anti-Skid Control is the use of the new Acetel resin in the manufacture of the unit. The exterior shell of the sensing unit is made from Delrin, a DuPont product which was chosen because of its toughness and strength and resistance to hydrocarbon.

"Interior parts are made from Zytel, another DuPont product giving high resistance to abrasive wear.

"By using these products Perma Research not only created a better product, but reduced the overall part costs by [illegible] per cent.

"The Perma-Vac housing and other metal parts are precision made under exact manufacturing specifications. Each part is carefully assembled and the unit tested for operational performance.

"There is no other anti-skid control unit commercially available on the market today. The Perma Anti-Skid Control is a perfected, patented device proved and accepted by safety officials as well as automotive engineers and mechanics.

"It is simple to install. Any semi-skilled

garage or service mechanic can install the unit in less than an hour with basic tools. It is self-lubricating, needs no maintenance. When purchasing a new car, the unit may be transferred from your old automobile. It can be installed on practically any car with conventional brakes or power brakes and on light trucks using hydaulic brakes.

"Thus, through imagination, engineering and precise product design and manufacture, Perma Research & Development Co. is providing new safety and a better brake with a Perma Anti-Skid Control.")

BY MR. BOORSCH:

Q Mr. Patten, you have just seen a copy of a film describing the Perma anti-skid device.

To the best of your recollection, is that the film or a copy of the film which was supplied by Perma prior to Singer's entering into the June contract?

A Yes.

Q That was supplied by Perma to Singer; is that correct?

A That is correct.

Q You saw it prior to the June contract?

DEFENDANT'S EXHIBIT 8

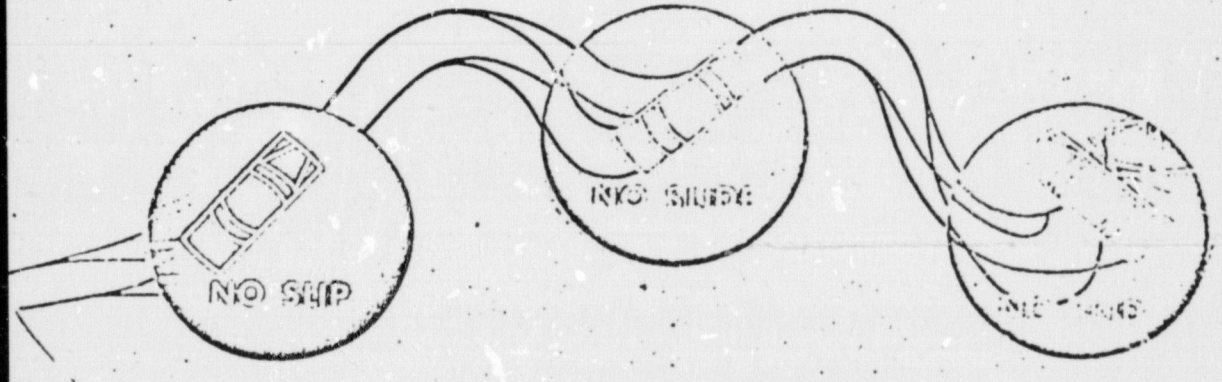
# FINALLY!

## A PRODUCT THAT PREVENTS SKIDDING

under all weather conditions and on all road surfaces due to overbraking

# PERMA

# ANTI-SKID CONTROL




## MOST REVOLUTIONARY SAFETY ADVANCE SINCE HYDRAULIC BRAKES

8

# CHECK THESE 12 KEY FEATURES

- ✓ ALL WEATHER — ALL ROAD SURFACES
- ✓ FULLY TESTED — fully tested - 1/4 million mile life
- ✓ MAINTENANCE FREE
- ✓ SIMPLE INSTALLATION
- ✓ AUTOMATIC OPERATION
- ✓ NO CHANGE IN DRIVER HABITS
- ✓ ONE YEAR WARRANTY
- ✓ TRANSFERABLE — to your next new car
- ✓ FAILSAFE OPERATION
- ✓ INSTALLS ON MOST CARS
- ✓ WITH OR WITHOUT POWER BRAKES
- ✓ USED NOW — on official vehicles, Federal, State and Police

EXHIBIT 135 10/4/66

#8

# 4 BIG SAFETY ADVANTAGES

during emergency braking

| | |
|---|---|
| ELIMINATE SKIDDING — | dry pavement, wet, gravel, snow, ice |
| GET SHORTER STOPPING DISTANCES — | under all weather and road conditions |
| MAINTAIN DRIVER STEERING CONTROL — | to you and your family during emergency stops |
| REDUCE DASHBOARD HAZARDS — | during panic stops |

#8

DEFENDANT'S EXHIBIT 10

PERMA RESEARCH AND DEVELOPMENT

1952 -.1962

1952 The first of Perma Research and Development Company's products was the automatic brakes, (a unit that applies an automobiles brakes automatically upon releasing pressure from the accelerator pedal).

This unit was originated seven years prior to incorporation by Frank Perrino, President of this Company.

While stationed with the United States Air Force in Germany this invention was in the idea stages.

1954 It wasn't until he returned to the United States and his home state, Rhode Island, that real development on this product started.

1955 Even the first crude model aroused the interest of many people who expressed their belief that this product was needed and a large potential existed.

1956 In the coming months the automatic brake was developed and a patent was applied for. Further capital was now required to exploit this invention. Mr. Perrino's patent attorney formulated an agreement whereby working capital could be obtained in exchange for a per cent of profits that might later be realized from his invention.

The people who saw this product demonstrated, expressed their enthusiasm, and some later purchased a percentage interest, realizing the risk involved and that it might take some time before any return could be expected.

This working capital permitted promotional efforts and expenditures such as further modifications of the product, patent coverage, trips with the patent attorney to companies that expressed their interest etc.

These trips did not result in a sale, but did result in some good constructive criticism, such as "what about safety features?" "What happens if I overbrake on ice?", etc.

1957 This criticism resulted in further development work and by-products which are now feature products such as the AUTOMATIC STARTER (for restarting a vehicle automatically in traffic stalling), An ANTI-SKID DEVICE (that senses the wheels starting to skid and releases just enough brake pressure to allow the wheels to roll. This allows the driver to steer and prevent the vehicle from spinning around into oncoming traffic, while still applying enough pressure to bring the ve

to a last controlled stop.

This further development, patent work, etc., resulted in the raising of additional funds on the same basis. As progress was made and new products added, the price of this percentage interest was increased because it was felt that the first investors had taken more of a risk and were therefore entitled to a larger interest. In fairness to the first people who purchased an interest in the Automatic Brake only their agreements were updated to include the new products.

1957 Interest in these products from Detroit automotive manufacturers resulted in further capital investment on the above basis for the new cars to be used as demonstrators, further patent protection and the many trips to Detroit that followed.

1958 These trips even with the interest expressed did not materialize in a sale.

It appeared that a better connection with the people on the proper level in these companies might be the answer.

Contact was made by one of the investors with a New York financier from Wall Street, a Mr. Arthur Lipper, who assured us he could do the job and there was no need to sell any further interest, as he would absorb all expenses.

At this time, it was decided by the promoters that a Corporation should be formed and if Mr. Arthur Lipper performed, he would be entitled to 15% of the Company.

Mr. Perrino also had commitments to people other than the investors who had helped in various ways.

The principals who were involved in active promotion of these products at this time were:

Frank Perrino, Inventor
Joseph Marino ) In manufacturing assisted Mr. Perrino
Paul Marino, Jr. )
Andrew J. White, Motor Vehicle Research Testing Laboratory
South Lee, New Hampshire
Arthur Lipper III, New York Financier

On July [illegible], 1959, a corporation was formed called Perma Research and Development Company, Inc.

The legal work was performed by Mr. Lippers attorney, a Mr. John McNiff of Shearman & Sterling & Wright, a law firm in New York.

The Corporation was incorporated in Delaware.

Authorization 400 shares common stock $1.00 par.

The first meeting of the Company was held at the Parker House in Boston, Massachusetts on July 7, 1959.

The Board of Directors were nominated as follows:

Frank Porrino, President & Director
1759 Louisquisetta Pike
Lincoln, R. I.

Joseph Marino, Secretary & Director
Angel Road
Lincoln, R. I.

Paul Marino, Jr., Treasurer & Director
Mineral Spring Avenue
North Providence, R. I.

Andrew J. White, Director
Epping, New Hampshire

John McNiff, Director

On July 9th, a second meeting of the Board of Directors was held at the Parker House, Boston, Massachusetts and the purpose of this meeting was to:

Establish a working agreement with Mr. Lipper and to satisfy all of Mr. Porrino's prior commitments.

The 400 shares of stock of the company were distributed as follows:

15 % or 60 shares reserved - A. Lipper
10% or 40 shares issued - A. J. White
42 shares issued - Joseph Marino
30 shares issued - Paul Marino, Jr.
15 shares issued - J. A. Kennedy
13 shares issued - V. Penta
190

The remaining 201 shares were retained by Mr. Porrino and the people who invested money with him prior to incorporation.

Prior to the issuance of the above 199 shares, Mr. Perrino requested these shares be put in a voting trust with him as voting trustee in order to maintain control of the company. All parties agreed and voting trust agreements were drawn up by Attorney McGiff.

The stock was registered with the securities division of the State of Rhode Island. Mr. Perrino filed for a brokers license in Rhode Island, which was granted and the stock was issued, except for investors who were out of town.

The money that remained from the percentage interest sales was used to purchase a new Rambler and miscellaneous equipment, as Mr. Lipper had set up appointments with American Motors and other companies which he felt would materialize in a sale.

Many trips to Detroit, Indiana and Chicago, and New York etc., resulted in still no sale to the motor companies. After some months of this type effort, it was decided not to pursue the original equipment market for the following reasons:

1. Long periods of testing and evaluation which we had already been through at heavy expense.

2. The fact that even if the fastest possible evaluation resulted in a positive reply, it would take years before any substantial royalties could be realized.

3. Automobiles are designed and tooled three to four years in advance.

4. There was always the possibility that even after all of these time consuming procedures there was no assurance they would buy or used these products.

It was now decided at a group meeting among the Directors to pursue the following course:

1. To finance the Company.

2. To manufacture the products.

3. To market the products.

~~Machinery of the company started in motion~~ to Wall Street and an attempt to find an investment house who would help frame to raise the necessary funds for:

1. Acquiring a building for machine shop, development work, sales and main office.

2. To purchase materials that would be needed to build an inventory of finished product.

3. To tool for the parts that could not be purchased on the open market.

4. To build a sales organization to market finished products and the overall overhead that building such an organization involves.

These trips to Wall Street and various contacts with investment houses did not result in the companies objective, therefore another method had to be found.

Mr. Lipper had 15% of the Company reserved for him upon performance, and his contract still had 8 to 10 months left to run.

Since the Company had no unissued stock there was none left to sell.

Mr. Perrino loaned his shares to the Company and started to sell shares at $5,000. per share with the help of the other Directors and stockholders.

During the activity of raising money and as far back as trying to interest Detroit, tests were being conducted by an independent testing laboratory (Motor Vehicle Research of New Hampshire). These tests ran from 1957 to 1959 with favorable results.

During this time, Mr. Perrio also was actively demonstrating for safety officials, registrars, news editors, magazine writers, etc.

These efforts resulted in publicity from all parts of the world.

A building was purchased in April 1960 and thoroughly remodeled to provide facilities for Research, development, sales and a main office.

All the necessary equipment was purchased and installed and market research work was conducted.

Contact was made with it's present manufacturer, Dunk Inc. of Attleboro, Reedin Corporation, South Bend, Indiana, Minneapolis Honeywell, Minneapolis, Minn., Eaton Manufacturing Co., Cleveland, Ohio, H. K. Porter, Boston, Mass., etc.

In order for the company to get its products on the market

at a price that the consumer could afford and yet provide a good profit, commitments for expensive tooling and large quantity orders had to be made.

Orders of 50,000 or more had to be placed in order to attract the cooperation of these large firms.

A firm contract was entered into with Swank Inc., whereby Swank would be responsible for tooling, molds and assembly of Perma's products, to be delivered no later than November 30, 1960.

All of this initial expense excluding finished parts was to be paid for from the sale of stock which was presenting no problem at this time.

This money was still being raised from the sale of the stock which Mr. Perrino had loaned to the Company. It was expected this stock would be returned when Mr. Lipper's contract had expired.

An agreement was reached prior to the expiration date of Mr. Lipper's contract whereby Mr. Lipper terminated his contract in return for 8 shares of stock.

The Company returned the shares it owed to Mr. Perrino, leaving a balance of approximately 11 shares unissued. The Company had sold for cash or had given for equity valuable services approximately 41 shares.

The 11 shares that remained would not provide sufficient capital to finance the entire program.

At a special directors meeting on June 20, 1960, it was decided that the Company should increase its' present authorized 400 shares and to split 1 for 2 all stock.

This increased a stockholders shares 1 for every 2 now held and gave the Company a new total of shares which it could sell, approximately 166.5.

A stockholders meeting was held on August 1960 and a vote approved the above proposal.

It was also voted by ~~suggestion of~~ the stockholders at this meeting that 20 shares of stock be reserved for issuance to Mr. Perrino at his discretion.

From incorporation to this date, none of the officers or Directors received any salary, although the Directors voted a small salary for Mr. Perrino. Instead, each Director sold some

of his own holdings to obtain required capital.

The payment to Perma's suppliers for product was to come from a network of franchised distributors who each would take a certain number of units thereby absorbing the units Perma had obligated itself to and also show a substantial profit.

This entire franchise program was formulated and Perma started to sign up Dealers. It had acquired approximately three dozen Dealership areas.

Dealerships were located in Rhode Island, Maine, Pennsylvania, Ohio, California, Massachusetts, etc., although only Rhode Island was completely saturated.

Rhode Island was the single largest contract whereby a corporation called Automotive Safety Service paid in advance $30,000. for franchise rights for the entire state and $26,000 for initial product orders.

The Dealers in the other states provided similar contracts although each was a smaller amount.

At approximately this time the Securities and Exchange Commission conducted an investigation of Perma Research and Development Company and advised the Company that the stock sales that were being made were in violation of the Securities Act.

That stock sales should be discontinued until a proper filing was made.

This put the Company in a position where it could not raise any further capital for the initial commitments that it had made, tooling, payroll, inventory of parts, advertising to support its sales organization, to sign up more Dealers, etc.

The Company had on hand approximately $80,000, but this wasn't even half of what was needed. The Company immediately cut back expenditures such as advertising, payroll, sales equipment, etc., but the inertia of prior commitments resulted in sales effort losses.

Also, Svank did not meet delivery schedules of product due to tooling production problems and others as agreed.

This put Perma in the position whereby it had considerable inventory on the shelves but no completed units that could be shipped to its franchised Dealers.

November now went into March and still production problems existed with its suppliers.

Perma therefore had no choice but to return the franchise money with interest and cancel orders.

The return of the money created good will and the company's credit and reputation was not impaired.

The first of Perma's products was now coming off the assembly lines, but Perma was not in a position to absorb too many of these units as it had no dealers and capital was running low.

A group of stockholders, when they heard of Perma's problems gave their services at no charge in order to conserve working capital. This increased Perma's staff by at least 20 people.

Some part time, others who were in retirement or owned there own business, full time.

Perma had been behind in much of its scheduled work and was now catching up.

During this trying period, an offer was made to management that a financial group desired to purchase management's stock for a total in excess of $350,000. and would employ Frank Perrino at $400.00 weekly to continue in an engineering capacity.

A few of the stockholders who were aware of the offer expressed their feeling of retaining present management. At the next Directors meeting held for this purpose, Mr. Perrino declined the offer which led to some disagreement between Directors.

The Directors expressed their desire to sell out and gave Mr. Perrino the opportunity to buy their stock at an attractive price. The transaction took place and new Directors were put in their place.

The new management was as follows:

Frank Perrino, President & Director
Richard Canning, Attorney with Lotts & Quinn, Secretary & Dir.
Robert Mainelli, Assistant Treasurer & Director
Edward Conaty, Treasurer & Director

This new management tried to find ways of interim financing.

A private offering was suggested and Mr. Canning being the Company's attorney and secretary made an appointment at the Boston Regional office of the Securities and Exchange Commission. After consultation, Mr. Canning expressed an affirmative reply providing certain conditions were met.

The company proceeded under these conditions which were set forth at a stockholders meeting August 26, 1961, which called for a new class of stock and to convert 50 of the present 750 common shares of stock to 50 shares of class A common stock and 700 common.

This stock was to be sold privately. Thirty three shares were sold to seventeen people for a total of $165,000 which allowed the company to proceed with tooling production, sales, etc. on a tight budget.

While at the same time preparing a filing with the Securities and Exchange Commission, so that the Company could go public with its stock.

The purpose of which was to provide capital to pursue the most profitable avenues of acquiring exclusive new patented products and marketing them.

The Company was continuing to solve its production problems and marketing and proceeded with its ground work. It would not actively set up new dealerships until products were fully ready for consumer use.

The Company acquired an underwriter from Pittsburg, Pa., who was to do the underwriting of its stock issue. A stockholders meeting was held and the filing was made with the Securities and Exchange Commission in Boston.

At this time, the Securities and Exchange Commission unexpectedly brought action against Perma Research and Development Company and Frank Perrino, as it construed the private offering of the Class A stock as a public offering.

Since the Companys underwriting would be delayed, a loan was obtained from the Small Business Administration (SBA) of $150,000 with which the Company is now operating.

The law firm of Fino and Ambrogne was retained to try to resolve by whatever legal means were necessary, the SEC's complaint so that the Company could continue to pursue a public offering on a sound basis.

In summarizing:

The position of the Company at this time is as follows:

1. Product is being shipped by Perma suppliers (Svank) on a slow but increasing basis stressing quality control procedures.

2. Prospective franchised dealerships are again being contracted to re-establish a network of product distributors.

3. It is just presently marketing new products (Hydraulic switch and automatic starter, etc.)

4. It is anticipating filing a registration statement with the S.E.C. to bring its stock to the public.

It will utilize the funds provided by this public offering to continue to promote its products.

It will continue to design and seek new products which can provide future growth for the Company.

DEFENDANT'S EXHIBIT 11

REC'D JUN 22 1964

FORD DIVISION

Ford Motor Company
ROTUNDA DRIVE AT SOUTHFIELD ROAD
DEARBORN, MICHIGAN

GENERAL SALES OFFICE

June 15, 1964

Mr. G. Lee Dienes
Perma Research and Development Company
345 E. Washington
North Attleboro, Massachusetts 02761

Dear Mr. Dienes:

This letter will confirm our discussion of last week regarding the effect on the Ford warranty of the installation of a non-Ford part. Specifically you are interested in knowing if the installation of the anti-skid device which you call "Perma Anti-Skid Control" affects the warranty on Ford vehicles. The installation and use of a non-Ford part on a Ford vehicle does not in and of itself void the vehicle warranty. However, if such installation or use contributes to or causes the premature failure of a component, the warranty on that component is void.

As I told you during our discussion, the above policy has been published to all of our field offices and through them to all of our dealers. The most recent publication of this policy was made in October, 1963, when all Ford dealers were advised in writing that the use of a non-Ford oil filter did not, per se, void the warranty on the vehicle. Although that letter dealt with oil filters, the same principle applies to the use of any non-Ford product.

Sincerely,

G. J. Salustro

G. J. Salustro

cc: Mr. J. L. Marley
Warranty Administration Manager
Lincoln-Mercury Division

E-1039 A

DEFENDANT'S EXHIBIT 12

SUMMARY OF TEST RESULTS: There were no significant differences either in minimum stopping distance or in directional stability caused by the Perma anti-skid control device when the vehicle was stopped on any test surface or at any test speed by a full and continuous application of brakes (spike-stop), as shown in the table below:

| Type of Surface | Vehicle Speed - mph | Minimum Stopping Distance - ft | | Directional Stability* | |
|---|---|---|---|---|---|
| | | Anti-Skid On | Anti-Skid Off | Anti-Skid On | Anti-Skid Off |
| Dry Asphalt | 10 | 10.6 | 8.5 | Stable | Stable |
| | 20 | 29.7 | 29.0 | | |
| | 30 | 54.0 | 53.0 | | |
| | 40 | 91.0 | 82.5 | | |
| | 50 | 130.0 | 128.0 | | |
| Soaped Paint-Strip | 10 | 23.7 | 20.0 | Stable Turned Left | Stable Turned Right |
| | 20 | 84.0 | 77.0 | | |
| | 30 | 199.6 | 194.3 | | |
| 2 Wheels on Dry Asphalt, 2 on Soaped Paint-Strip | 10 | Stopping distance not calculated because vehicle was completely out of control | | Out of Control | Out of Control |
| | 20 | | | | |
| | 30 | | | | |

* With reference to direction of travel
Coefficient of Friction - Tire to Dry Asphalt - 0.7)
Coefficient of Friction - Tire to Soaped Paint-Strip - 0.14

VEHICLE DATA:

| | |
|---|---|
| Make and Model | 1964 Ford 4-Door Sedan |
| License No. | RP 3673A (Massachusetts) |
| Engine | 289 CID, V-8, 2-V |
| Transmission | Cruise-O-Matic |
| Tires | 7.50 x 14 (24 psi front and rear) |
| Test Weight | 4393 lb (2227 lb front, 2166 lb rear) |
| Special Component | Perma Anti-Skid Control System |

PROCEDURE: The vehicle was instrumented with wheel rotation counters, a pressure pickup, fifth wheel, accelerometer, and oscillograph.

Brake tests were conducted at the Dearborn Proving Ground and the results recorded with an oscillograph under the following test conditions:

1. Spike-stop - dry asphalt surface - vehicle speeds of 10, 20, 30, 40 and 50 mph - anti-skid device operating and not operating

2. Spike-stop - two soaped paint-strips approximately 18 in. wide, 230 ft long - vehicle speeds of 10, 20, and 30 mph - anti-skid device operating and not operating

3. Brakes pumped - two soaped paint-strips - vehicle speeds 10, 20, and 30 mph. (Anti-skid device necessarily off during this test since its effect is to pump the brakes automatically.)

4. Spike stop - Vehicle placed with two wheels on dry asphalt, 2 wheels on paint strips - vehicle speeds of 10, 20, and 30 mph - anti-skid device operating and not operating.



[DX 12, p 1]

[illegible]

[illegible]

Brake Test Data with and without Anti-Skid Control Device - [illegible]

| Surface | Anti-Skid Control Device | Vehicle Speed (mph) | Type of Brake Application | Minimum Stopping Distance (ft) | Deceleration ft/sec² | Brake Line Pressure - psi Max. | Brake Line Pressure - psi Min. | *Directional Stability |
|---|---|---|---|---|---|---|---|---|
| Dry Asphalt | Off | 10 | Spike-stop | 8.5 | 23.60 | 825 | None | Stable |
| | | 20 | | 24.0 | 24.00 | 840 | | |
| | | 30 | | 53.0 | 25.20 | [illegible] | | |
| | | 40 | | 82.5 | 25.60 | 840 | | |
| | | 50 | | 123.0 | 24.25 | 856 | | |
| | On | 10 | | [illegible] | [illegible] | [illegible] | 100 | Stable |
| | | 20 | | 26.7 | 24.90 | 860 | 190 | |
| | | 30 | | 54.0 | 25.40 | 847 | 195 | |
| | | 40 | | 91.0 | 22.15 | 750 | 200 | |
| | | 50 | | 130.6 | 22.60 | 842 | 260 | |
| Soaped Paint-Strips on Asphalt | Off | 10 | | 20.0 | [illegible] | [illegible] | None | Stable |
| | | 20 | | 95.0 | 5.15 | 850 | | Turned [illegible] |
| | | 30 | | 194.5 | 5.60 | 854 | | |
| | On | 10 | | 23.5 | [illegible] | [illegible] | 77 | Stable |
| | | 20 | | 94.0 | 4.80 | 657 | 69 | Turned [illegible] |
| | | 30 | | 199.6 | 4.92 | 711 | 53 | |
| | Off | 10 | Pumping | 27.0 | [illegible] | [illegible] | [illegible] | Stable |
| | | 20 | | 106.0 | 4.30 | 470 | 30 | Turned [illegible] |
| | | 30 | | 199.0 | 5.20 | 560 | 25 | |
| Wheels Dry Asphalt Paint Wheels on Soaped Paint-Strip | Off | 10 | Spike-stop | Minimum stopping distance, deceleration and brake line pressure not calculated because vehicle was completely out of control | | | | Completely Out of Control |
| | | 20 | | | | | | |
| | | 30 | | | | | | |
| | On | 10 | | | | | | |
| | | 20 | | | | | | |
| | | 30 | | | | | | |

* With reference to the direction of travel

Coefficient of Friction between the tire and dry asphalt 0.59
Coefficient of Friction between the tire and soaped paint-strip on asphalt 0.14

DEFENDANT'S EXHIBIT 20

AMERICAN MOTORS CORPORATION

14250 PLYMOUTH ROAD • DETROIT MICHIGAN 48232

June 26, 1964

DX 20-XR

12-4-77

Mr. Roger Levesque
Avenue E - R.F.D. #1
Lincoln, Rhode Island

Dear Mr. Levesque:

Your letter of June 3 eventually reached my desk, since in Automotive Engineering we are familiar with the particular Anti-Skid device you are referring to. So far, we have conducted tests of the Perma device only in a limited number of models, and have not authorized its use as an official Rambler service accessory.

In many instances of this general nature, the new car warranty might be affected, if the device in question was of such a nature as to affect the functioning, reliability and durability of other components of the vehicle. Accordingly, we can make no blanket endorsement of all after-market products adaptable for use on Ramblers, unless they have been officially approved as Rambler accessories.

However, to correct a common misconception, installation of an after-market product on a Rambler does not automatically void the car warranty. Only if later adverse performance effects develop in vehicle systems which are traceable to the after-market product as a cause, would the warranties be voided in the system of which the after-market product becomes a component.

In this case, we are familiar with the Perma Anti-Skid device, and have reviewed warranty provisions with their representatives. However, we recognize there may be cases where such an installation might adversely affect the life of certain of our components, which then would not be subject to warranty replacement. For example, it may be possible for an improper field installation to be made, resulting in a configuration such as a short bend in the speedometer drive cable, a faulty brake line or some other adverse condition. A failure of a speedometer cable under these conditions, for instance, would not be subject to a warranty replacement.

You will find that other car manufacturers give the same basic interpretation of effect on car warranties by installation of after-market components. The interpretation and conditions expressed in this letter are consistent with the terms defined in our official dealer warranty, specifically, the exclusion under item (3) of our warranty.

We hope this serves to clarify the situation to your satisfaction, and that you will find many pleasant motoring miles in your new 1964 Ambassador.

Sincerely,

L. H. Naglor
Staff Engineer - Safety

LHN:vh

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DEFENDANT'S EXHIBIT 25

SPECIAL REPORT II

Confidential

TO: Frank Perrino
Vincent Imbrella
Joe Perrino
Joseph Stronach

FROM: Thomas Perrino

Information on failure of Anti-Skid device in field.

REPORT # 1:

Owner: Danny Pugliese - employee of Perma Research and Development Company

Auto: 1969 Plym...th VB - automatic transmission

Installation: Perma Research and Development Company

Problem: Complete loss of brakes on application- intersection-stop sign. Car involved in accident with another vehicle, 2 passengers bruised, one in each car.

Cause: Stripped Delvin drive gear, gear binding on cam gear in top position causing micro switch and solenoid to engage and not release.

Solution: Unit taken out of car - new installation later.

REPORT # 2:

Owner: Joseph Perrino, Safety Service Corporation

Auto: 1969 Chevrolet Chevelle Malibon V8 SS Automatic-Transmission (Demonstration car)

Installation: Perma Research & Development Company

Problem: Anti-Skid not pumping at all times (poor demonstrator)

CAUSE: Unit tested, pumped twice and pin sheared in gear box.
Inspection on Anti-Skid showed #8-10 worm in half and locked on top of cam gear, preventing cam gear from rising. (Also, lack of lubrication)

Solution: Installed new gear box and Anti-Skid unit. (well lubricated)

REPORT #3

DX 25

(text of DX 25, p 1 transcribed on page E-1044A)

" SPECIAL REPORT II

Confidential

TO: Frank Perrino
(?)
(?)
(?)
Joseph (?)

(?): Thomas Perrino

Information on failure of Anti-Skid device in field.

REPORT #(?): Owner: Danny(Paglicao?) - employee of Perma Research and Development Company

Auto: (1969?) Plymouth V8 - automatic transmission

Installation: Perma Research and Development Company

Problem: Complete loss of brakes on application intersection-stop sign. Car involved in accident with another vehicle, 2 passengers bruised, one in each car.

Cause: Stripped (Delvin?) drive gear, gear binding on (one?) gear, in top position causing micro switch and (solenoid) to engage and not release.

Solution: Unit taken out of car - now installation later.

REPORT #(?): Owner: Joseph Perrino, Safety Service Corporation

Auto: 1964 Chevrolet (Chevello Mc ?) V8 SS Automatic Transmission (Demonstration car)

Installation: Perma Research & Development Company

Problem: Anti-Skid not pumping at all times (poor demonstrator)

CAUSE: Unit tested, pumped twice and pin sheared in gear box. Inspection on Anti-Skid showed RS-10 mm in half and (?) on tone of cam gear, preventing cam gear from rising. (also, lack of lubrication)

Solution: Installed new gear box and Anti-Skid unit. (well lubricated)

REPORT #(?):

REPORT #6

Owner: Paul Proccaccini, Walpole, Massachusetts

Auto: 1966 Chevrolet Wagon - automatic transmission

Installation: Perma Research and Development Company

Problem: Broken speedometer cable and unit not working. (Customer was not aware of Anti-Skid not functioning)

Cause: 1. Sharp bend in speedometer cable. (causing inside cable to wear out.

2. Hydraulic pressure switch leaking through brass.

3. Could not complete 12 volt circuit through hydraulic pressure switch using 0 to 1000 PSI and voltmeter reading .002 volt.

Solution: Installed new speedometer cable. Checked gear box and adapter and installed new hydraulic pressure switch. Also checked out Anti-Skid unit for wear. Blew out dust and relubbed. Installed bobbin in unit.

Road tested - okay.

Submitted by,

Thomas Perrino

REPORT #(?):

Owner: Paul Proccoccini, Walpole, Massachusetts

Auto: 1964 Chevrolet Wagon - automatic transmission

Installation: Perma Research and Development Company

Problem: Broken speedometer cable and unit not working. (Customer was not aware of Anti-Skid not functioning)

Cause: 1. Sharp bend in speedometer cable. (causing inside cable to wear out).

2. Hydraulic pressure switch leaking through (levers?)

3. Could not complete 12 volt circuit through hydraulic pressure switch using 0 to 1000 PSI and voltmeter reading .002 volt.

Solution: Installed new speedometer cable. Checked gear box and adapter and installed new hydraulic pressure switch. Also checked out Anti-Skid unit for wear, blow out, dust and relubbed. Installed bobbin in unit.

Road tested - okay.

Submitted by:

/s/ Thomas Perrino
Thomas Perrino"

DEFENDANT'S EXHIBIT 36

DEFEX 73

# FIELD REPORT

July, 1964

TO: Mr. Porrino
Mr. Malnelli
Mr. Krawczyk

TECHNICIAN: Roger Levesque
Tommy Porrino

Installation of steel drive gears in Connecticut State Police Cruisers.

WESTPORT BARRACKS:

Replaced nylon drive gear with steel c 3 oz-17285-c, used 18T adapter — good mesh.
Found drive train coupling grooved within by flexible cable - countersunk coupling.

First road test - release at 2 1/2 T Cam Gear - set cam gear at 4 T.

Second road test - excellent, also on sand.

BETHANY BARRACKS:

Replaced nylon drive gear with steel c 3 oz-17285-c, replaced 18T adapter - seriously sheared. Set cam gear at 4 T.

Road test - excellent.

Changed Anti-Skid unit - foreign matter - precaution.

REMARKS: Trooper Hassler experienced loss of brakes (hard pedal) at 85 M.P.H. Trooper was clocking two speeders when he noticed loss of speedometer - interferring auto cut across path of cruiser..trooper had to apply brakes three times before standard brakes took hold.

PERSONAL THEORY: Nylon adapter gear sheared as indicated by loss of speedometer--this reaction simulated a wheel lock condition to the Anti-Skid unit causing cam gear to rise and trip micro-switch. Trooper applied brake pressure closing 12 volt circuit via hydraulic pressure switch. Hydraulic fluid may have been trapped - possibly 200 PSI or more. Hydraulic pressure switch could not break 12 volt circuit,, thus incomplete cycle.

Power-vac piston remained in 1/2 cycle position causing loss of brakes.

STAFFORD SPRINGS BARRACKS:

Replaced nylon drive gear with steel c Nox-17285-c.

FIELD REPORT -2-

Found both gears in good condition as this is a new cruiser with approximately 150 miles.

Set cam gear at 4 T.

Road test - excellent.

HARTFORD BARRACKS:

Trooper Shaw

Replaced nylon drive gear with steel # 3oz-17285-c.

Found both gears in good condition as this also is a fairly new cruiser - 700 miles. This cruiser also has not been on highway patrol as Trooper Shaw is on special detail at Headquarters.

Road test - excellent.

NOTE: Had to return to every barracks to check adaptor shaft clearance per orders Robert Vainolli - had enough clearance between shaft and housing boss.

Roger Levesque

Thomas Perrino

FIELD REPORT

TO: Frank Perrino
Robert Mainelli
Joseph Krawczyk
Leo Dicnco

DATE: 7/14/64
7/15/64

Technician: Thomas Perrino

Assignment: Connecticut State Police - Westport Barracks - c/o Safety Service Corporation - To replace plastic speedometer gear with steel replacement gear.

AUTOMOBILE: (1) One 1964 Ford V8 Cruiser Interceptor - 3 speed standard transmission.

TIME: Home departure 6:30 A.M. - arrived at barracks 10:00 A.M.

PROBLEMS: Had to borrow motor jack from local ford dealer. Removed rear housing of transmission to replace gear. Assembled and replaced new adapter. Both gears were stripped. Tested Anti-Skid, worked, but on normal stop Anti-Skid pumped - checked sensing unit to see if Micro-Switch was set wrong, noticed at this time that skid was not lubricated. Set switch and lubed. Also found that flex-drive cable was wearing into coupling - repaired. Tested with same results.

Inspected adapter gear - found it stripped, not meshing correctly. Tried different adapters, (gears) with no luck.

SECOND DAY: Disassembled transmission. Found that new steel drive gear was undersized. Tried to secure correct gear at Ford Dealers from New Haven to New York Border. Some dealers said they had them, only to arrive and find they were mistaken. Discussed Anti-Skid with Parts Managers and found that they had all heard of it. Some had read up on it. All co-operated fully.
Being unable to secure correct steel gear I disassembled transmission again and installed new original plastic gear. Disconnected flex-cable and 12 volt circuit but left Anti-Skid in car. Also left new adapter and gear box in car so that speedometer would work, thus allowing them to use car.

COMMENTS: Was able to speak to Patrolman at this time when he came off duty. Explained to him trouble encountered and apologized to him for his inconvenience. Patrolman assured me at this time that he would not condem Anti-Skid until we had problem

solved and car fixed. Had full co-operation with all concerned.

CORRECT GEAR SIZE WILL COMPLETELY SOLVE THIS PROBLEM.

DEPARTURE: 7:00 P. M. July 15th, Newport Barracks. Arrived home 10:30 P.M.

Respectfully submitted,

Thomas Perrino

DEFENDANT'S EXHIBIT 44

FIELD REPORT August 27, 1963

Confidential

TO: Frank Perrino
Robert Mainolli
Joseph Krawczyk
Leo Dionne
Sam Karp

TECHNICIAN: Roger Lovesque

ASSIGNMENT: Investigate failure in field - replace complete Anti-Skid Unit.

AUTO: Dodge 880 - 1963 V8 Automatic Transmission - Power Steering Power Brakes

OWNER: Mr. Leo Le Blanc

PROBLEM: Loss of brakes - hard pedal

COLLISION: One auto - in front at approximately 3 miles per hour.

CASUALTIES: None

COST: Approximately $25.00

REMARKS: (Told to Mr. Perrino and retold to me)
Mr. LeBlanc had just returned from a trip to the mountains. Upon his arrival home, he then experienced loss of brakes with a hard pedal. Loss of brakes resulted in a collision with another auto at approximately 3 miles per hour. Information not known before, was that Mr. Le Blanc had been experiencing releases at end of normal stop quite frequently - at this particular moment the release was extensive.

Mr. Le Blanc quite concerned related he was very happy this incident did not occur while driving down the mountain roads, as he referred to the many "hairpin turns."

POSSIBLE CAUSE: Anti-Skid drive shaft misaligned badly with drive train cover binding entire drive assembly. ///S set at 65"

PERSONAL COMMENTS: Seriously, let's put our heads together and put a priority on a fail safe feature or future such incidents may prove to be fatal.

Roger Lovesque

E-1050

DEFENDANT'S EXHIBIT 53

UNITED STATES DISTRICT COURT

SOUTHERN DISTRICT OF NEW YORK

PERMA RESEARCH & DEVELOPMENT COMPANY,

Plaintiff,

-against-

THE SINGER COMPANY,

Defendant.

66 Civ. 665

AFFIDAVIT IN OPPOSITION

STATE OF RHODE ISLAND )
: ss.:
COUNTY OF PROVIDENCE )

FRANK PERRINO, being duly sworn, deposes and says:

1. I am President of Perma Research & Development Company ("Perma"), plaintiff in the above entitled action, and I submit this affidavit in opposition to defendant Singer's motion for summary judgment. Defendant's motion papers are a virtual repetition of an application previously denied by the Hon. Frederick van Pelt Bryan, United States District Judge on July 15, 1968. As on the prior motion, defendant's motion papers misconstrue the contract between the parties which is the subject of this suit and ignore the essential facts underlying this suit. The purpose of this affidavit is to set forth those facts.

2. In July 1959 I caused the incorporation of Perma to engage in the manufacture and sale of products for the auto-

#53



[DX 53, p 1]

motive industry. By 1963 the Company's principal product was a patented automobile anti-skid device which when connected to the braking system prevented skidding caused by wheel lock-up. When brakes were applied with force sufficient to lock the wheels and cause skidding, Perma's anti-skid unit immediately released just enough hydraulic pressure to unlock the wheels. The device would then, in alternation, restore and release hydraulic pressure, maintaining it at the point of maximum braking just below skid producing pressure, until the automobile came to a straight controlled stop. In effect, the invention mechanically pumped the brakes several times per second, far faster and with more control than man could pump them, allowing a car to stop without skidding on any road surface, wet or dry, in distances shorter than or at least as short as were attainable without the device. The invention incorporated principles used in anti-skid devices installed in military and commercial aircraft and was a revolutionary advance in automobile safety.

3. By early 1964, Perma had approximately 400 shareholders who had invested approximately $730,000 in cash for their shares and at least $3,000,000 worth of service and materials. Thus, for example, shares were given in consideration of raw materials, tooling, manufactured product, equipment, advertising and printing. Shares were also given for valuable services of engineers, mechanics, lawyers and others who advanced the interests of the Company. As a result, prior to June 1964, Perma had 772 shares outstanding. These shares were being bought and

sold at $5,000 per share giving a market value to said outstanding shares of approximately $3,860,000.

4. By June 1964, the Perma Anti-skid unit had been extensively tested and promoted and was being manufactured commercially on dies, moulds and other tooling built for Perma at a cost of over $180,000, approximately two-thirds of which had been paid for by Perma. The Worcester Stamped Metal Company ("Worcester") was Perma's prime contractor under a contract entered into on August 2, 1963. Over twenty vendors manufactured parts which were delivered to Worcester in various stages of assembly. Manufacture of certain parts, final assembly and testing of components were performed by Worcester. Perma handled the promotion and sale of the product and, under its contract with Worcester, the latter was paid for the product only after Perma had received payment from its customers.

5. Under these arrangements, Perma had marketed approximately 3,500 Anti-Skid units before the Singer Company replaced Worcester as Perma's prime contractor. Prior to contracting with Singer, Perma had orders from certain of its distributors calling for the delivery of over 40,000 Anti-Skid units within a year. The delivery price was approximately $59.00 per unit, approximately 40% of which represented gross profit to Perma. Perma retained all marketing rights until December 21, 1964, by which time Perma's contracts with distributors covered firm orders or minimum requirements to retain franchise rights for in excess of 225,000 units. In addition, Philips Petroleum

Co. was planning to distribute the unit through its dealers and, as a result of market surveys, estimated sales through its dealers at over 19,000 units a month, or in excess of 228,000 per year. Other prospective customers such as the United States government and major automobile manufacturers were testing the unit when Singer replaced Worcester as prime contractor, and Perma, pursuant to initial orders, had already supplied the United States Post Office Department in Providence, Rhode Island, and Washington, D. C. with a limited number of units.

6. Singer initially contacted Perma in February, 1964 (after having seen demonstrations of the product in Canada) and sought to obtain the manufacturing rights to the Anti-Skid unit, telling Perma that Singer then had surplus manufacturing capacity. To induce Perma to substitute Singer for Worcester as prime contrator, Singer volunteered to assume Perma's obligation to purchase the components of 50,000 units from Worcester and its vendors. Perma was interested in Singer being associated with its product because of (1) the world famous Singer name and reputation, (2) its great size and consequent ability to meet the greatly expanded production requirements anticipated for the unit and (3) the unique production quality control and testing services which, according to Singer, it could and would provide because of its extensive manufacturing experience and technical skills. Perma had experienced some problems in these areas under its contract with Worcester and was assured by Singer that, if it replaced Worcester, these problems would be eliminated. In

the contract entered into between Singer and Perma on June 18, 1964, Perma retained all marketing rights and Singer assumed complete responsibility for manufacturing, including "diligent quality control in the production, assembly, testing and packaging" of the product (June 18, 1964 Contract ¶ 10).

7. In exercising these responsibilities, Singer had the right "at any time to change vendors and suppliers" (June 18, 1964 Contract ¶ 4). Initially it chose not to do so but to continue using those used before June 1964 because it had assumed Perma's obligations to purchase 50,000 units from these suppliers. When Singer replaced Worcester as prime contractor, most of the parts for these units were not yet manufactured, and only a small percentage of those parts had been assembled into components. Singer had been advised prior to June 1964 of quality control problems which had previously been encountered with these suppliers and of the resulting necessity for close quality control; Singer was specifically authorized to reject parts not made to specifications (See June 18, 1964 Contract ¶ 10). Again, in July 1964, after parts for only a few thousand units were manufactured and assembled into components under the complete control of Singer, Perma called Singer's attention to the fact that the units then being delivered by Singer continued to have the exact defects previously encountered. Nonetheless, Singer continued to permit the manufacture and assembly of units without following proper quality controls until by October 1964, 50,000

unmarketable units had been produced and assembled. For example, Singer did not even perform on-site inspection in the plants where the various parts were built. Random sampling of these units by month of manufacture revealed manufacturing defects such as missing parts, parts not made to specification, faulty soldering, misaligned, assemblies, etc., in over 75% of the units inspected. With the exception of a few shipments totaling approximately 2,000 units, most of which were defectively assembled and had to be retrieved, no units were shipped to customers in 1964 after Singer replaced Worcester as prime contractor. As a result Perma received no income during this period. From June through November, 1964, however, Perma continued to incur overhead and other expenses at the rate of more than $20,000 per month which, in the absence of income, forced it into desperate financial condition.

8. Singer, at p. 3 of its Memorandum in Support of Defendant's Motion for Summary Judgment, seeks to absolve itself of responsibility for the failure to ship units in 1964 by (1) erroneously suggesting that the 50,000 units it allowed to be assembled without proper quality controls were an existing "inventory of some 50,000 specified component parts" as towhich Singer's only duty was one of testing after assembly, and (2) by claiming that the defects which appeared in these parts had their origin in design and not in manufacture and assembly and thus were the responsibility of Perma. However, as set forth above,

Singer's duty was one of diligent quality control in the production and assembly of the parts as well as testing after assembly and if fulfilled would have prevented the assembly of 50,000 defective units. To demonstrate that the defects were attributable to Perma, Singer claims these defects required "Perma to make some twelve design changes." However, those so-called design changes were nothing of the sort. For the most part they represented Perma's widening of permissible deviations from written part specifications at Singer's request to allow Singer to utilize incorrectly manufactured parts. In only one instance did the parties decide that Perma should be responsible and pay the cost of a change. This change was not a design change which occurred after Singer became prime contractor but one which had been made long before and had simply not been physically incorporated on to the written specifications which Perma delivered to the fabricator substituted by Singer. This alone and not "12 design changes" was attributable to Perma and was corrected as early as September 1964. Singer still failed to manufacture and ship product throughout 1964. Other changes made by Perma were not required because of design defects but consisted of new ways to extend the life of the product, adapt it to new-model cars and simplify production at the request of Singer.

9. As Perma's financial condition deteriorated, Perma agreed to surrender marketing as well as manufacturing rights to Singer and, on December 21, 1964, the parties entered into a

new contract which terminated the June 1964 contract. Singer had assured Perma that, if it acquired marketing as well as manufacturing rights, it would be able to (1) alleviate Perma's financial problems, (2) hire more people experienced in the automotive brake field and (3) invest additional monies toward the manufacture and marketing of the product.

10. Under the new contract Perma assigned its applicable patents to Singer and was to receive royalties based initially on a fixed dollar amount per unit sold by Singer, and thereafter for 10 years on a percentage of the factory invoice price. The contract, although silent as to Singer's duty to manufacture and market the product, required it "to use its best efforts" to do so (Deft. Memo. p. 9). Only the "method" of manufacturing and marketing the product was left to Singer's "absolute discretion". In the event that Singer spent less than $100,000 annually on the advertising and promotional aspects of marketing the product, commencing with the year 1966, then for that breach Perma had the right to reassignment of its patents upon the payment of $50,000 and of certain amounts previously advanced by Singer on its behalf. This provision was included to assure Perma only that "there would be some advertising and promotion done by Singer" (Perrino Dep., pp. 211-12).

11. This provision was not addressed to Singer's duty to manufacture and ship units and was not intended to define that duty. It does not even mention the year 1965, during

which Perma certainly expected Singer to be manufacturing and shipping units and during which Singer was additionally obligated to do so by virtue of its having assumed Perma's obligations under five distributor contracts assigned by Perma to Singer simultaneously with the execution of the December 21, 1964 contract. These contracts alone called for the delivery by Singer of in excess of 50,000 units during 1965. And by July 1965, Singer was writing distributors and customers to assure them that, after having encountered certain problems, Singer now had a "product worthy of offering to the public" on which a full marketing campaign would commence within 60 days. See e.g., Exhibit "A", attached hereto. It was after this that Singer, having failed to manufacture and deliver any units under the December contract, abandoned its contract with Perma claiming for the first time that the Anti-Skid unit was not 100% fail-safe.

12. This occurred in October 1965, over one and one-quarter years after Singer had first contracted to manufacture and deliver Perma's Anti-Skid device, after Perma had modified the device to deliver increased pressures to be required in as yet unproduced automobiles which would have disc brakes requiring higher pressures and after extensive tests by Singer in the spring and summer of 1965 which demonstrated stopping distances for cars equipped with the device to be consistently shorter than or equal to those achieved on a car not equipped with the Anti-Skid device.

13. Whether the device was "fail-safe" when Singer decided not to market it is the core of the present dispute between Perma and Singer. I of course firmly believe that it

was. When Perma initially contracted with Singer, the unit had fail-safe mechanisms in both the sensing unit and the vacuum can. In the spring of 1965 an additional fail-safe mechanism was installed as part of a transfer valve which was designed in anticipation of the automobile industries move to disc brakes in 1966. When Singer tried in October 1965 to avoid its contract by claiming for the first time that the unit, despite these various fail-safe mechanisms, was not 100% failure proof, Perma designed yet another back-up fail-safe mechanism which Singer refused to test. Singer's refusal to test a car equipped with this mechanism demonstrates that its real concern was not whether the unit was fail-safe. Singer tries to exploit my having stated on deposition that "if the unit is not made properly...there could be a loss of brakes, yes" as an admission that the unit was not fail-safe. My statement was, of course, nothing more than an acknowledgment that a mechanical product not built correctly may not function. Thus, for example, if power brakes fail because of loss of hydraulic fluid resulting from a defectively assembled power unit, there may be also a total loss of brakes and not a reversion to the primary braking system. This demonstrates not an absence of a fail-safe feature but a lack of sufficient quality control in manufacturing and testing particular units.

14. At pages 4 and 18 of its Memorandum Singer points to the fact that I agreed in November 1965 that all existing units, including pre-Singer units, should be retrieved from the field and participated in a retrieval program as proof that the units were not fail-safe and thus not marketable. It is, of course, nothing of the kind. As described above fail-safe features will not prevent mal-function if the necessary quality controls are lacking and the mechanism is improperly manufactured or assembled. It was in part because Perma's suppliers in 1964 were not exercising the necessary quality controls that Perma agreed that Singer should replace Worcester in June 1964. Since, for this reason, the possibility of improperly manufactured units existed as to the pre-Singer as well as to Singer-made units, I agreed to their retrieval. It had nothing to do whatever with the fail-safe question.

15. Finally, Singer points to Perma's refusal to accept reassignment of its patents and claims that if the product had been a viable one surely Perma would have accepted the return of its patents in preference to this lawsuit. In making this claim, Singer ignores the terms of its own offer and that its conduct had effectively prevented Perma from again proceeding to manufacture the product. By virtue of Singer's failure to market the product, Perma had been virtually without sales income from June 1964 to November 1965. To cut overhead, Perma had during this period reduced, or lost, most of its engineering, sales and

and office staffs. Singer refused to deliver to Perma the thousands of units it had on hand to provide Perma with a production base even though approximately 5,000 of those units were the property of Perma. It refused to restore Perma to the position it was in before Singer approached it in February 1964. To have done just this, without including the value of the 1-3/4 year competitive jump which Perma lost as a result of its encounter with Singer, would have cost in excess of $2,000,000. In other words, acquiring and training new staff, developing advertising and dealer exposure, and prototyping the unit for current automobile models would in 1965 have cost at least this amount. Singer, however, offered merely to reassign Perma's patents and defer Perma's payment of $250,000 to Singer. In addition, Singer insisted on a release by Perma of all claims against Singer. To have accepted Singer's offer would have been contrary to the best interest of Perma's many shareholders. Perma had no funds with which to exploit the patents, and no product with which to commence operations. To surrender its readily provable claims for damages against Singer under these circumstances could not be justified. Among the additional damages caused by Singer's breach were (1) lost profits on firm orders for between 40,000 and 83,000 units depending on the date used to measure them; (2) lost profits on between 225,000 and 338,000 units (depending on the date used to measure them) required to be purchased as a condition to maintaining franchise

agreements; and (3) lost profits of many more millions of dollars properly calculable on the basis of Perma's prior marketing and sales experience, demonstrated distributor interest, and market surveys demonstrating a demand for literally millions of units. In addition, the uniqueness of the Perma Anti-Skid device and its extraordinary good will during the early 1960's led to favorable news coverage and publicity in the following nationally distributed magazines, among others: Newsweek, Popular Mechanics, Popular Science, Mechanix Illustrated, Parade, This Week, Motor Trends, Motor Life, Automotive News, Fleet Management News.

This good will, in the absence of production for 5 years has been completely lost. Furthermore, Singer's unwarranted rejection of the Anti-Skid device and its erroneous statements that the device was not fail-safe further injured Perma's good will. Finally, Singer by preventing Perma from exploiting what was then a unique product deprived Perma of the advantages of being many years ahead of competition. In short, Singer's breach has effectively eliminated Perma and its unique product from the market place.

Frank Perrino

Sworn to before me this
16th day of November 1969

Notary Public

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

OFFICE OF THE CLERK OF THE
SUPERIOR COURT

PROVIDENCE, 11-19 A. D. 19 69

PROVIDENCE, SC.

I, ANGELO A. ADAMO, Deputy Clerk of the SUPERIOR COURT of said State for the Counties of Providence and Bristol, the same being a Court Record and having by law a seal,

DO HEREBY CERTIFY, that Anthony T. Jackvony whose name is subscribed to the annexed certificate was at the time of signing said certificate a NOTARY PUBLIC in and for said State of Rhode Island duly appointed and qualified, and authorized to administer oaths and take depositions and to take the acknowledgment or proof of deeds or conveyances of lands, tenements or hereditaments lying in said State and which deed or conveyances are to be recorded in said State; that I am well acquainted with the handwriting of said Anthony T. Jackvony and verily believe that the signature to the said Certificate, purporting to be his, is genuine; that the laws of said State do not require the use of a seal by a notary and no copy of a notary's seal is on file or required to be on file in this office.

In attestation whereof, I hereunto subscribe my name, and affix the seal of said Court, the day and year above written.

Angelo A. Adamo Deputy Clerk.

After viewing all available copies of the preceding page, counsel for Appellant believes that said page reads as follows:

July 7, 1965

Mr. C. G. Morehouse, Vice President
MARSH & MC LENNAN, INC. OF OREGON
Standard Plaza
Portland, Oregon 97204

Dear Mr. Morehouse:

The delays associated with shipment of your Anti-Skid Control are unfortunate but unavoidable.

After acquiring the patents to the control, a controlled marketing was started in the local area. Very frankly, some problems arose with regard to the function of the product. Most significant of these was a tendency for a lag or reduced braking at the end of the control cycle. It was found this was associated with the design of some of the 1965 braking systems. A modification to the unit was required and started at once. In the meantime, we had begun to pursue the automotive manufacturers for OEM application and product approval. Detroit requested a modification to the unit. They desired a greater output pressure from the control to answer two problems. First, a serious glazing or fading of brake linings would require higher output pressures that we offered. Secondly, with the trend toward disc brakes, greater output pressure was desirable.

The solution to both conditions required changes in the Perma-Vac section of the Control. Redesign and modification was completed and a test program instituted. As is not uncommon, a new problem arose. Stopping distances with the control on dry roadway increased over those without the control. We certainly could not market the product without notifying our customers of this increased distance even if we did, under all conditions, give him steering control and reduced stopping distances except for dry roadway.

We have tackled this problem and resolved it. The present unit being released for production does give equal or shorter stopping distances at all speeds in excess of 30 mph. At 30 mph you give up some stopping distance some of the time. Our test results at this speed were mixed. We feel the variables present as to road, tire and lining

NGER CO PANY ELIZABETH, NEW JERSEY

Mr. C. G. Morehouse - 2 - July 7, 1965

conditions make panic stops at this speed or slower difficult to compare on run-to-run. The average difference in stopping distance at these speeds on a variety of vehicles is less than 5% and, in most instances, is measured in inches.

We feel we have a product worthy of offering to the public and plan a full marketing campaign for September with limited production and sale starting within the next 3 to 4 weeks. If you desire, we can no doubt ship your unit prior to August 1st.

We hope this has helped to explain the delay and brings you up-to-date on the program status.

Yours very truly,

R. R. PATTEN
Manager
Factory Sales

RRP/dk

cc: Mr. J. Holley

E-1065



After viewing all available copies

ing page, counsel for Appellant believes tha

as follows:



conditions make panic stops at this speed or
to compare on run-to-run. The average diffe
distance at these speeds on a variety of veh
than 5% and, in most instances, is measured

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public and plan a full marketing campaign fo
limited production and sale starting within
weeks. If you desire, we can no doubt ship
to August 1st.

We hope this has helped to explain the
you up-to-date on the program status.

Yours very

R. R. PATT
Manager
Factory Sa

RPP/dk

cc: Mr. J. Kelley

E-1065A

Sir:—

Please take notice . . de within is a true copy of a

duly entered herein in the office of the Clerk o

19

Dated, N.Y., 19

Yours, etc.,

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for

Office and Post Office Address
777 Third Avenue
Borough of Manhattan, New York City 1001.

To , Esq.

Attorney for

---

Sir:—

Please take notice that the within

ill be presented for settlement and signature herein to the Hon.
one of the judges of the within named Court, at

in the Borough of
City of New York, on the day of
19 , at M.

Dated, N.Y., 19

Yours, etc.,

P TTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for

Office and Post Office Address
777 Third Avenue
Borough of Manhattan, New York City 10017

To , Esq.

Attorney for

---

Index No. Civ. 665 Year 19 66

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

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PERMA RESEARCH & DEVELOPMENT COMPANY,

Plaintiff,

-against-

THE SINGER COMPANY,

Defendant.

---

AFFIDAVIT IN OPPOSITION TO MOTION FOR SUMMARY JUDGMENT

---

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER

Attorneys for Plaintiff,

Office and Post Office Address
777 Third Avenue
Borough of Manhattan, New York City 10017
MUrray Hill 8-3200

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COPY RECEIVED
Dec 4 1967
The Singer

[DX 53, p 17]

E-1066

DEF EX 103

Mr. R. Kloby,
Department 166

J. Gomes,
Department 195

July 23, 1964

Perma Anti-Skid Unit

Dear Sir:

I have been advised by Mr. R. Minelli of Perma Research, that there are 1200 of the new design gear boxes that are no good and are not to be used unless corrected. Prior to receiving this information, we were under the impression that all gear boxes of the new design were good.

On Monday, July 27th, we will contact American Optical to find out if these 1200 can be identified in someway other than having to disassemble all Gear boxes on hand.

The reason that the 1200 gear boxes are considered no good is that the pinion shaft hole of the gear box housing (Perma Part No. GB-1) was made to a .313 to .315 size. This was changed to .315/.317 after the first 1200 were made. At that time a decision was made to use the first 1200, however, Perma now finds that at 85 m.p.h. the unit heats up sufficiently to cause a binding condition between the pinion shaft and gear box housing.

Very truly yours,

MECHANICAL ENGINEERING DEPARTMENT

J. Gomes
Assistant Chief Engineer

JG/ms

cc: Messrs. R. R. Patten
N. Rhojony
H. Snyder
A. Romel

RECEIVED
JUL 27 1964
FACTORY SALES

~~PX-37~~ FD-102 5/6/74

DEFENDANT'S EXHIBIT 111

SINGER
321 FIRST STREET · ELIZABETH, N. J.

MEMORANDUM

TO: Mr. C. W. Brocker, Assistant General Manager
Manufacturing Division

FROM: A. Romel, Department 195

DATE: October 26, 1964 REFER TO:

SUBJECT: "Gear Boxes" for Perma Anti- Skid Units

Dear Sir:

Attached is a summary of completed and current tests performed to date on gear boxes. I suggest that a meeting be held to discuss the results of these tests.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel

A. Romel, Manager
Manufacturing Engineering
Contract Sales

AR/ms

cc: w/encl.

Messrs. C. S. Morris
J. Fecko
H. Snyder, Jr.
G. Plungis
H. Sharp
R. Kloby
R. R. Patten
J. Moore

D-111 id

PX-411 id

October 26, 1964
8:00 A.M.

## SUMMARY OF GEAR BOX TESTING

### A/O Boxes - Modified by Quaker City Gear

| Gear Box | Accumulated Mileage | |
|---|---|---|
| #1 | 2959 | Ran at a speed of 95-100 m.p.h. |
| #2 | 5310 | |
| #3 | 8905 | |
| #4 | 1420 | Ran at a speed of 85 m.p.h. |
| #5 | 7440 | |
| #6 | 2816 | Ran at a speed of 73 m.p.h. |

#4 A/O — A/O Box - All shaft holes were enlarged .005 above shaft size.

Accumulated mileage 9065. The first 139 miles were at 73 m.p.h., the remainder at 85 m.p.h.

All of the above showed excessive gear wear. The modified Quaker City Gear Boxes had a partial oilite bearing on the pinion shaft.

All of the above gear boxes failed.

The following have an oilite bearing the full length of the pinion shaft pressed into the Delrin housing.

| | | | |
|---|---|---|---|
| #7 | 5240 | Failed<br>(Gear Ratio)<br>1:1-1/2 | Operated at a speed of 80 m.p.h. Gear teeth were worn beyond point of engaging. Gear and shaft were pinned. |

| Gear Box | Accumulated Mileage | | |
|---|---|---|---|
| #8 | 12953 | Failed (Gear Ratio) 1:1-1/2 | Operated at a speed of 73 m.p.h. Gear teeth were worn beyond point of engaging. Approximately 10,000 cycles of intermittent starting and stopping were inflicted on this box. Gear (driving) was held by a set screw and loctite. This held. |
| #9 | 8500 | Failed (Gear Ratio) 1:1-1/2 | Operated at a speed of 80 m.p.h. Gear teeth were worn beyond point of engaging. Roy Dean lube was used. |
| #10 | 17528 | Operating (Gear Ratio) 1:1-1/2 | Showing some signs of gear wear. Lubriplate (Aero) type is used. Operating at a speed of 80 m.p.h. |
| #11 | 8522 | Operating (Gear Ratio) 1:1-1/2 | Showing signs of excessive gear wear. Operating at a speed of 80 m.p.h. Gear is pinned to shaft. |

All of the above gear boxes have brass gears.

| Swank - Gear Box | | | |
|---|---|---|---|
| Swank #1 | 1536 | Failed | 9/18/64<br>Speedometer reading at start of test 1327.6 - ran at 74 m.p.h. The test stand was stopped at 2254.4. A total of 926.8 miles traveled.<br><br>9/21/64<br>Increased the speed to 97 m.p.h. - the pin sheared off immediately. Stopped the stand at 2254.8.<br><br>The gear box was taken apart - found excessive wear on both gears. |

| Gear Box | Accumulated Mileage | |
|---|---|---|
| | | The hub face was worn irregular from .352-.350 in spots. |
| | | The hub face riding against the gear box housing wore a groove in the housing. |
| | | The gear shaft showed signs of out - off roundness as did the holes in the housing. |
| | | .0005 to .001 .0005 to .001 |
| | | The pinion shaft pilot showed a wear off .0002. |
| | | 9/21/64 The gear box was assembled and "Aero" type lubriplate grease was packed into the housing. The speed was reduced to 70 m.p.h. and test stand started. Speedometer reading was 2254.8. |
| | | The test stand was stopped with the speedometer reading 2863.7 - Monday night - 9/21/64. |
| | | In the morning of 9/22/64 - the test stand was restarted but the gear box was inoperative. Upon disassembly it was found that the gears were worn beyond the point of meshing. A total of 1536 miles were traveled. |
| Swank #2 | 17528 Operating (Gear Ratio) 1:2 | Showing some signs of gear wear. Lube #175 used. Operating at a speed of 80 m.p.h. |

| Gear Box | Accumulated Mileage | | |
|---|---|---|---|
| Stewart | 17528 | Operating | Sealed unit - unable to observe gear wear. Operating at a speed of 80 m.p.h. |

From all A/O Gear Boxes modified by Quaker City Gear as well as the Swank Gear Box, show signs of leaking lubrication.

Each Sensing Unit show signs of grease entering thru the connecting cable.

A/O - Modified by Quaker City Gear

| | | | |
|---|---|---|---|
| #13 | 2900 | Operating | Brass pinion gear - Steel driving gear - Lubriplate (Aero) grease. Operating at a speed of 72 m.p.h. |
| #14 | 2900 | Operating | Steel pinion gear - Brass driving gear - Lubriplate (Aero) grease. Operating at a speed of 72 m.p.h. |
| #15 | 2900 | Operating | Brass pinion gear - Brass driving gear - Mil. grease 3278 used. Operating at a speed of 72 m.p.h. |
| #16 | 2900 | Operating | Steel pinion gear - Steel driving gear - Mil. grease 3278 used. Operating at a speed of 72 m.p.h. |

Def. Ex. 115

DEFENDANT'S EXHIBIT 114

Mr. C. W. Brooker - Assistant General Manager
Manufacturing Division

A. Romel - Manager - Department 195

November 16, 1954

"Gear Boxes" for Ferro Anti-Skid Unit

Dear Sir:

Attached is a summary of gear box test results to date. Numbers 27 thru 29 represent the latest design. Numbers 22 and 23 will be tested to failure in order to attain data for comparison.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel

A. Romel, Manager
Manufacturing Engineering
Contract Sales

AR/ms

cc: w/att. summary

Messrs. C. S. Morris
J. Fecko
R. Kloby
H. Snyder, Jr.
G. Plungis
R. Patton
J. Moore
H. Sharp

General Fabrication Division
Manufacturing Engineering
Contract Sales

November 16, 1964 AR/ma

## SUMMARY OF GEAR BOX TEST

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| Stewart | 50,904 | Operating | Sealed Unit - unable to observe gear wear.<br>Operating at a speed of 80 m.p |

### A/O - MODIFIED BY QUAKER CITY GEAR

| | | | |
|---|---|---|---|
| #13 | 23,002 | Operative | Brass Pinion Gear - Steel Driving Gear - Lubriplate (Aero) Grease.<br>Operating at a speed of 72 m.p.<br>Off Stand. |
| #14 | 20,520 | Operative | Steel Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease.<br>Operating at a speed of 72 m.p.<br>Taken off Stand to make room for Gear Box #29. |
| #22 | 21,499 | Operating | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease.<br>Operating at a speed of 80 m.p.<br>Gear teeth show definite wear.<br>End play .005 start.<br>End play .010 present time. |
| #23 | 21,499 | Operating | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease.<br>Operating at a speed of 80 m.p.<br>Gear teeth show definite wear.<br>End play .005 start.<br>End play .013 present time. |

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| #24 | 13,726 | Failed | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. Teeth on Gear and Pinion wore out. |
| #25 | 18,382 | Operative | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. Gear teeth show slight wear. End play .005 start. End play .013 present time. Taken off Stand to make room for Gear Box #27. |
| #27 | 5,367 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h Gear teeth show definite wear. End play .005 start. End play .005 present time. |
| #28 | 1,235 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 72 m.p.h Gear teeth show slight wear. End play .004 start. End play .004 present time. |
| #29 | STARTED | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h End play .005 start. |

GEAR BOX - MADE BY BOSE MECHANICAL LABORATORIES

| | | | |
|---|---|---|---|
| Alum. Housing with Oilite Bearing and Oilite Thrust Washer | 16,710 | Operative | Brass Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 72 m.p.h Gear teeth show definite wear. Off Stand. |

DEFENDANT'S EXHIBIT 115

SINGER
235 FIRST STREET • ELIZABETH, N. J.

MEMORANDUM

TO: Mr. C. W. Brocker - Assistant General Manager
Manufacturing Division

Quaker City

FROM: A. Romel - Manager - Department 195

DATE: November 24, 1964 REFER TO: AR:ms

SUBJECT: "Gear Boxes" for Perma Anti-Skid Unit

RECEIVED
NOV 27 1964
FACTORY SALES

Dear Sir:

Attached is a summary of gear box test results to date. These tests are run at room temperatures. We are presently taking steps to test gear boxes at different temperatures in that we have found that the Delrin housing expands and contracts with temperature changes. Samples from a recent shipment have been cooled to - 10°F and tried for freeness. In all cases a binding condition developed to an extent that a pair of pliers were needed to turn the shaft. The lubricant was not frozen.

A discussion with Quaker City representatives about this problem resulted in their recommendation of changing the backlash from .004 max. to .005/.008. All future shipments from Quaker City will have the added backlash. It is our intention to life test some of these to determine the effect of increased backlash at high running temperatures. Results will be forwarded to you as soon as they are available. We recommend that the use of these boxes be held in abeyance until these tests are concluded.

The Stewart gear box was disassembled. We found that they are using hardened steel helical gears with oilite bearings for shaft support. Both gears are mounted inboard which affords much greater stability than the cantilever construction used in the Perma design. The bearings are mounted in a bored aluminum die casted housing which also helps stabilize the unit.

We have not received the six Stewart samples from Mr. Moore to date and therefore have only tested one unit. Additional units must be tested to verify the results obtained on this box.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel

A. Romel, Manager
Manufacturing Engineering
Contract Sales

Encl.

cc: C. Mungia
R. Parker
J. Moore
H. Sharp
C. S. Morris
J. Fecko
R. Kloby
R. Snyder, Jr.

DX 115

General Fabrication Division
Manufacturing Engineering
Contract Sales

November 24, 1954 AR/ms

## SUMMARY OF GEAR BOX TEST

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| Stewart | 56,000 | Failed | Gears didn't fail but showed definite signs of wear. Box was removed because grease from adjoining boxes hardened around gears and caused it to bind. Unit was disassembled. |

## A/C - MODIFIED BY QUAKER CITY GEAR

| | | | |
|---|---|---|---|
| #2 | 26,419 | Failed | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. Gear teeth show definite wear. End play .005 start. End play .010 present time. |
| #23 | 33,032 | Operating | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. Gear teeth show definite wear. End play .005 start. End play .013 present time. |
| #27 | 16,800 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h Gear teeth show definite wear. End play .005 start. End play .005 present time. |

DX 115 Stet

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| #28 | 11,776 | Operating | Steel Pinion Gear - Brass<br>Driving Gear - Mil. Grease 3278 used.<br>Operating at a speed of 72 m.p.h.<br>Gear teeth show slight wear.<br>End play .004 start.<br>End play .004 present time. |
| #29 | 11,433 | Operating | Steel Pinion Gear - Brass<br>Driving Gear - Mil. Grease 3278 used.<br>Operating at a speed of 80 m.p.h.<br>End play .002 start.<br>End play .0035 present time. |

NO MATERIAL ON PAGE E-1079

DEFENDANT'S EXHIBIT 118

Mr. C. W. Drocker - Assistant General Manager
Manufacturing Division

A. Monel - Manager - Department 195

December 3, 1964 ARims

"Gear Boxes" for Perma Anti-Skid Unit

Dear Sir:

Attached is a summary of gear box life test results to date. Please note that we are again testing a unit to determine whether the set screw on the gear will withstand shock loads. We have done this before but feel additional tests are required due to a recent complaint from the field. The problem is probably one of proper control by the vendor. He has been notified by Mr. Moore of the complaint.

The problem of tight or binding gear boxes apparently has not been corrected by the vendor since a large percentage of units are being rejected for this defect.

A test set-up is being designed to environmental test gear boxes between a temperature range of -15°F to 200°F. Static torque tests have revealed that the torque required to turn gear boxes at -15°F is increased by a factor of ten times that required at room temperatures. Details of these tests are attached. We are presently taking steps to determine whether the plastic gears on the adaptors will withstand this load. We recommend that the use of these units be held in abeyance until this information is available.

We have not received the six sample units from Stewart to date.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Monel, Manager
Manufacturing Engineering
Contract Sales

Att.

cc: Messrs. J. Fecko R. Patten
D. Adams J. Moore
R. Kloby H. Sharp
C. Plemmis

D 118.

General Fabrication Division
Manufacturing Engineering
Contract Sales

December 3, 1964 AR/ms

## SUMMARY OF GEARBOX TEST

## A/O - MODIFIED BY QUAKER CITY GEAR

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| #23 | 50,212 | Operating | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. Gear teeth show definite wear. |
| #27 | 34,030 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h. Gear teeth show definite wear. |
| #28 | 27,281 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 72 m.p.h. Gear teeth show slight wear. |
| #29 | 28,613 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h. |
| #30 | 16,810 | Operating | Same as above. |
| #31 thru #35 | 1,463 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used, w/Retaining Collar. Operating at a speed of 80 m.p.h. |
| #36 | Cycle intermittently 4300 times | Operating | Same as above. |

## GEAR BOX TORQUE TEST

### Running Torque - 1000 R.P.M.

| | Room Temp. | - 15°F |
|---|---|---|
| Sensing Unit | 1.5 in./oz. | 10 in./oz. |
| Gear Box: | | |
| S-J-4 (Loose) | 1.8 in./oz. | 20 in./oz. |
| S-J-4 (Medium) | 2.5 in./oz. | 17 in./oz. |
| S-J-4 (Tight) | 2.0 in./oz. | 20 in./oz. |
| S-K-4 (1) | 1.8 in./oz. | 24 in./oz. |
| S-K-4 (2) | 2.5 in./oz. | 25 in./oz. |
| S-K-4 (3) | 2.8 in./oz. | 20 in./oz. |
| S-K-4 (4) | 4.0 in./oz. | Over 50 in./oz. |

DEFENDANT'S EXHIBIT 191

EXHIBIT 776
11/21/66 W.B.

THE SINGER COMPANY

ELIZABETH PLANT • 261 FIRST STREET, ELIZABETH, NEW JERSEY • 201 EL 2-9900

October 21, 1964

MFG. DIVN.
NOV 9 1964
ANS.

Mr. S.J. Murphy, Assistant Vice-President
The Singer Company
Manufacturing Division
30 Rockefeller Plaza
New York 20, New York

Dear Mr. Murphy:

The attached report outlines our present position under a manufacturing licensing agreement with the Perma Research & Development Company and the alternative courses of action now open to us regarding our future relationship with this company.

In view of the very small additional investment requirements, potential profit margins and implications inherent in each alternative, it is recommended that we continue to negotiate with Perma toward concluding a new agreement along the lines shown in this report.

We shall await your advice on this matter before proceeding further.

Yours very truly,

C.S. Morris

Cecil S. Morris
General Manager

CSM:hl
Encl.

Robert A. Kloby
October 21, 1964

PERMA ANTI-SKID CONTROL DEVICE
LICENSING AGREEMENT

MFG. DIVN.
NOV 9 1964
ANS.

On June 18, 1964 The Singer Company's Elizabeth Plant entered into a two-year licensing agreement with the Perma Research & Development Company for the exclusive manufacturing rights to the Perma Anti-Skid Control Device. Because of quality problems encountered in parts supplied by outside vendors and a design deficiency in a gear box, which was uncovered by our Quality Control testing procedure, only a token shipment of 500 units has been made to date. These problems appear to be resolved and shipments should resume before the end of October. However, during this time Perma has continued with its marketing program without benefit of cash flow from product shipments to offset the expenses being incurred. Perma has now reached the point where they cannot continue with their marketing and engineering programs without benefit of new financing.

As an alternative to refinancing, Perma has offered a proposal which would allow us to expand the scope of our present licensing agreement and substantially increase our potential profit margin.

Perma Proposal

Although many details of an expanded licensing agreement remain to be worked out, pending approval to proceed along these lines, Perma's offer is basically as follows:

Perma would give to Singer all rights in the United States to its Anti-Skid Control and the patents covering this device. Our rights under the existing agreement cover manufacturing only at a fixed selling price to Perma. The present price of $35.00/unit becomes renegotiable after 50,000 units and the contract expires after 250,000 units, or in June 1966, whichever comes first.

In return for these rights and the additional potential profits accruing to Singer from them, Perma would expect to receive a royalty payment for each unit sold based on the following schedules:

$10.00 per unit for the first 300,000 units.

15% of Singer's selling price for the next 200,000 units. Based on estimated prices at that point, this should amount to about $6.00 or $7.00 per unit.

10% of Singer's selling price per unit for each additional unit sold over the remaining life of the original patent (present life—13 years). It is estimated that this should amount to about $3.00 per unit.

Original equipment manufacturers' sales are subject to separate negotiations.

In addition to the aforementioned royalty arrangement, Perma is asking for a cash payment of approximately $150,000 to liquidate their current liabilities. The major liability is the balance of $82,000 on a Small Business Administration loan. It is highly desirable, if not mandatory, that these liabilities be liquidated primarily because of prior liens and SBA limitations on concluding such agreements.

Singer Proposal

Contingent upon approval in principle to proceed, we feel that the following counterproposal will serve as an acceptable basis for continuing

with negotiations toward an expanded licensing agreement with Perma.

Based on our present costs and Perma's lowest selling price, as well as anticipated cost reductions, the aforementioned royalty schedule is, in our opinion, acceptable. This will be shown in detail in a later exhibit.

A cash payment, independent of royalties, to liquidate Perma's liabilities is not acceptable. As a practical matter, however, some arrangement would have to be made to take care of these liabilities if and when an agreement was reached. We would propose periodic advance royalty payments sufficient to meet Perma's current obligations but not to exceed $150,000 in total.

As part of such an agreement, Singer would be assuming additional engineering responsibility such as prototyping of new model cars, testing, and further product development and refinement. Perma is presently adequately set up to perform these services. It would be desirable and probably less costly from our standpoint to have Perma provide these services for a one year period under a technical services contract. The annual cost of such a contract is estimated at less than $100,000.

When Singer-Elizabeth entered into the present licensing agreement with Perma in June of this year, it was recognized that an element of risk did exist. As in all subcontracting situations, Singer-Elizabeth was required to build some inventories and make purchase order commitments in order to fabricate the product. The maximum extent of our liability in these commitments approximates $500,000. The risk element centers around the fact that Perma's assets could not adequately support their commitment to Singer covering these

inventories in the event no units could be sold. As units are sold, our investment in materials diminishes almost proportionately and after 50,000 units the risk element becomes relatively small. Considerab e evidence exists in addition to distributor contracts with Perma to make us quite confident that many times more than 50,000 units can be sold.

At the present time, as well as prior to our contract with Perma, it is felt that the potential profits, even in the short run, far outweigh the potential risk.

As previously mentioned, a situation has evolved wherein Singer-Elizabeth now has an opportunity to change the terms and conditions of its present licensing agreement with Perma.

Ba ically, two alternatives are open to Singer-Elizabeth:

1. To continue to operate under our present manufacturing licensing agreement and inform Perma to seek new financing.

2. To expand our agreement to include marketing as well as manufacturing rights.

The investment requirements, product costs, degrees of responsibility, profit margins and implications inherent in each of these alternatives are outlined below:

Market Potential

In order to establish a basis for subsequent calculations, an estimate of the market potential for the product is necessary. Our

conservative estimates of the potential for the next five years is as follows:

| | | |
|---|---|---|
| 1st Year | - | 50,000 Units |
| 2nd Year | - | 100,000 Units |
| 3rd Year | - | 200,000 Units |
| 4th Year | - | 200,000 Units |
| 5th Year | - | 200,000 Units |

Some of the factors which were considered in arriving at these figures were:

Passenger car registrations - 70 Million.

Annual new car production - 7.5 Million.

St. Johns estimate Canadian market at better than 16,000 units per year and will purchase at least this many sets of components from Singer-Elizabeth in first year.

Endorsement by safety councils and insurance company associations.

Documented evidence of strong interest shown by fleets and government agencies.

Existing distributor contracts.

Sales to date of 2,000 units.

Alternative A

Continue under Present Agreement

Our present selling price and manufacturing cost are as follows:

| | |
|---|---|
| Selling Price/Unit | $35.00 |
| Singer Cost/Unit | 30.00 |
| Profit Margin | $ 5.00 |

Total Profit Margin
for 1st Year (50,000 Units) $250,000

Our manufacturing cost of $30.00/unit includes material, labor, quality control, product testing, product engineering for cost reduction purposes and overhead at full absorption.

Under the terms of our present contract the selling price of $35.00 becomes negotiable after 50,000 units. It is felt that, at best, we can expect to maintain our present $5.00/unit margin.

Based on the estimated potential and assuming a $5.00 margin can be maintained in negotiations over the next five years, the total profit margins are as follows:

| Year | Units | Total Margin |
|---|---|---|
| 1st | 50,000 | $ 250,000 |
| 2nd | 100,000 | 500,000 |
| 3rd | 200,000 | 1,000,000 |
| 4th | 200,000 | 1,000,000 |
| 5th | 200,000 | 1,000,000 |

However, our present contract expires after 250,000 units, or in June of 1966, whichever comes first. If sales approach our estimates, it is most likely that we will be bidding competitively with other companies at that time, resulting in a lower margin and possibly loss of the contract.

Since Perma has provided all of the tooling for this product, Singer-Elizabeth investment is as previously mentioned, confined to parts inventories and purchase order commitments. After the first 50,000 units are shipped, our investment in inventories and purchase order commitments should not exceed $100,000.

Alternative B

Expand Present Agreement

Under an expanded licensing agreement along the lines of the proposal previously outlined, Singer-Elizabeth would assume the marketing and engineering responsibility but would also substantially increase the profit margin. The increased margin as well as the additional cost of assuming these functions for the first 50,000 units are as follows:

| | Per Unit | Total First 50,000 Units |
|---|---|---|
| Selling Price | $51.00 | $2,550,000 |
| Manufacturing Cost | 30.00 | 1,500,000 |
| Engineering Cost | 2.00 | 100,000 |
| Marketing Cost | 3.00 | 150,000 |
| Profit Margin | 16.00 | 800,000 |
| Royalty | 10.00 | 500,000 |
| Profit Margin | 6.00 | 300,000 |

$51.00 is Perma's price to warehouse distributors. Prices to fleets and government agencies range from $60.00 to $80.00 per unit.

By contract, the responsibility and cost of servicing, local advertising and sales promotion is borne by the distributor. $1.50 per unit at distributor level is earmarked for advertising.

After the first 50,000 units, when some very unfavorable purchase order commitments are satisfied, the manufacturing cost should drop to around $22.00 per unit. After 300,000 units, this cost should be down to about $15.00 per unit. In any event, it has been conservatively estimated that a $6.00/unit margin can be maintained on the first 50,000 units and better than $10.00/unit on all additional units. Expressed in total profit margins, this amounts to the following:

| Year | Units | Total Margin |
|---|---|---|
| 1st | 50,000 | $ 300,000 |
| 2nd | 100,000 | 1,000,000 |
| 3rd | 200,000 | 2,000,000 |
| 4th | 200,000 | 2,000,000 |
| 5th | 200,000 | 2,000,000 |

Singer-Elizabeth investment in inventories remains the same as in Alternative A.

Advance royalty payments would have to be made to liquidate certain liabilities, the total amount not to exceed $150,000. This becomes an investment risk for up to the first 15,000 units only, the royalty then reverts to a "pay-as-you-go" situation.

The additional engineering expense can be handled by virtue of an engineering service contract with Perma. The total annual cost should be under $100,000 and payments can be made on a quarterly basis.

The marketing expense at the outset would not exceed the cost of adding three people to our Sales Department, plus their travel expense. The monies presently being expended by the distributors for sales promotion and advertising should suffice until a better measure of market acceptance can be gotten. Total marketing expense for the first 50,000 units should not exceed $150,000, with the option of curtailing this at anytime that it appears desirable to do so.

In view of the foregoing, it is recommended that Singer-Elizabeth continue its negotiations with Perma toward concluding an expanded licensing agreement.

DEFENDANT'S EXHIBIT 195 (PAGES 1-4) Def. Ex. 137

PERMA
RESEARCH AND DEVELOPMENT COMPANY

345 WASHINGTON, NORTH ATTLEBORO, MASSACHUSETTS 02761
AREA 617 TEL. 699 4602 - AREA 401 TEL. 725-6300

November 30, 1964

Mr. Robert Patten
The Singer Company
321 First Street
Elizabeth, New Jersey

Dear Bob,

Attached is an estimated budget projection that I feel would effectively kick off the marketing program.

The advertising program must be put into effect at once so that distributor inquiries may be generated immediately.

Please call on me if you require clarification or explanation.

Sincerely,

Sam Karp

Sam Karp
Vice President, Marketing

SK:so
enc.

D-195

D-195 id

PERMA RESEARCH AND DEVELOPMENT COMPANY, NORTH ATTLEBORO, MASSACHUSETTS



November 30, 1964

## BUDGET PROJECTION

Advertising:

1st month - Wall Street Journal - Eastern and Mid West Editions - 2 column X 4"
2 adds each week for 4 weeks

$1,120. each week - Total for 4 weeks $4,480.

4 - 7 X 10" Adds-
Automotive News
$644.00 each week - Total for 4 weeks $2,576.

2nd month - Cut above advertising by 50%
Wall Street Journal
1 - add each week for 4 weeks $2,240.
2 - 7 X 10 Adds Automotive News $1,288.

$10,584.

This proposal is for 2 months and should generate enough interest to keep us busy until early summer. I do not believe further trade advertising would be required until August or September of 1965.

PERMA RESEARCH AND DEVELOPMENT COMPANY, NORTH ATTLEBORO, MASSACHUSETTS



November 30, 1964

BUDGET PROPOSAL

| Show and Exhibitions: | | | Annually |
|---|---|---|---|
| I.A.S.I. Show (International Automotive Service Industries) and 1 other show. | | | $ 500.00 |
| Membership M.E.M.A. (Motor Equipment Manufacturers Association) This membership a requirement to participate in I.A.S.I. Show | | | 300.00 |
| **Traveling-Entertainment:** | | **Monthly** | |
| Expenses - (3 men) | Estimate | $ 2,500. | 30,000.00 |
| Telephone - | Estimate | 600. | 7,200.00 |
| Miscellaneous - (Mailing, Petty cash, supplies, etc.) | Estimate | 100. | 1,200.00 |
| | | | $39,200.00 |

Estimated Annual Total (this page)

PERMA RESEARCH AND DEVELOPMENT COMPANY, NORTH ATTLEBORO, MASSACHUSETTS



November 30, 1964

## BUDGET PROPOSAL

Sales Promotion Material:

As shown on attached inventory list $ 9,600.00

NOTE: Most of the above investment may be re-couped because of re-sale to distributors.

Exception would be the convention display.

Future Requirement:

An assortment of Dealer Newspaper Mats - Est. 1,200.00

NO MATERIAL ON PAGE E-1097

DEF. EX. 47.

DEFENDANT'S EXHIBIT 197

December 11, 1964

Mr. Ed Wright
Car Controls, Inc.
2762 West Bancroft Street
Toledo, Ohio

Dear Ed:

No need now to hold back. The new product is in high production and the quality and performance is great. I would recommend you put your efforts in high gear and take advantage of the weather. You may count on all of us at Perma to help in any way possible.

Ford Police cars no longer present a problem. You may use the new production units with confidence. The only thing you must be careful of is to make sure the car uses a STEEL gear on the drive shaft. If it is equipped with a plastic gear then obtain a steel duplicate from any Ford Dealer and proceed with installation in the usual manner.

We have prototyped the F100 Ford 3/4 Ton Truck with a V8 engine. We will prototype the V6 model within a week or 10 days. Your men may solicit business for this model Ford and we will make them available.

For Cone's information, we will ship on Monday, December 14th the 7 Bendix Hydrovacs direct to the Kettering Police Department Garage via Truck Prepaid.

Ed, please bear with us about one more week and I will take care of your inventory from Dayton. By the time you receive this letter, we will probably have signed the agreement with Singer and my job relative to the return of that product will be much easier. Be assured that I will send you a telegram advising you of the signing and immediately after I shall give you shipping instructions for the Dayton Armature inventory.

Sincerely,

PERMA RESEARCH AND DEVELOPMENT COMPANY

San Karp,
Vice President, Marketing

SK:jb

DEFENDANT'S EXHIBIT 233

DEFE. 118.

SINGER

221 FIRST STREET • ELIZABETH, N. J.

MEMORANDUM

TO: Mr. C. W. Broeker - Assistant General Manager
Manufacturing Division

FROM: A. Romel

DATE: December 23, 1964 REFER TO: AR:ms

SUBJECT: "Gear Boxes" for Perma Anti-Skid Unit

Dear Sir:

Attached is a summary of gear box life test results to date.

We have had no premature failures with the steel and brass combination of gears. The accumulated mileages indicate that the wear problem has been resolved. The tests will be continued to failure, for quantitive comparison purposes, on the American Optical units now on test. Wear testing of American Optical boxes will be terminated when these tests are completed. Testing of Stewart type gear boxes will be continued to verify the previous acceptable test results.

A maximum permissable torque requirement of 6 in.-oz. at 70°F ± 10° has been established by this department on American Optical gear boxes. Boxes which do not meet this specification are to be run-in at 1000 R.P.M. for ten minutes. This procedure was tried and proved satisfactory. The new gear box test stand can be used for this operation. Sample gear boxes obtained from F. W. Stewart registered 2 in.-oz. when subjected to torque tests at room temperature. A slight increase was noted upon cooling the units but they still met the specification.

Torque tests taken on several adaptors indicate that they should withstand the loads applied. We were unable to shock load these units but Perma indicates they have had no failures to date. The 21 tooth adaptor which we discussed as being too weak has been eliminated.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel

A. Romel, Manager
Manufacturing Engineering
Contract Sales

cc: D. A. Adler
O. Blundo
R. Patten
J. Moore
H. Sharp

Att.: Summary

DX 118 rd

D-233 rd

DX 233

General Fabrication Division
Manufacturing Engineering
Contract Sales

December 21, 1964 AR/ms

## SUMMARY OF GEAR BOX TEST

## A/O - MODIFIED BY QUAKER CITY GEAR

| GEAR BOX | ACCUMULATED MILEAGE | | |
|---|---|---|---|
| #23 | 69,000 | Failed | Brass Pinion Gear - Brass Driving Gear - Lubriplate (Aero) Grease. Operating at a speed of 80 m.p.h. |
| #27 | 65,588 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h. |
| #28 | 55,231 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 72 m.p.h. |
| #29 | 60,121 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used. Operating at a speed of 80 m.p.h. |
| #30 | 48,312 | Operating | Same as above. |
| #31 | 32,721 | Operating | Steel Pinion Gear - Brass Driving Gear - Mil. Grease 3278 used w/Retaining Collar. Operating at a speed of 80 m.p.h. |
| #32 | 32,721 | Operating | Same as above. |
| #33 | 32,721 | Operating | Same as above. |
| #34 | 32,721 | Operating | Same as above. |

233

| GEAR BOX | ACCUMULATED MILEAGE | |
|---|---|---|
| #35 | 24,478 | Taken off to make room for Stewart Gear Box. |
| #36 | Cycled intermittently 7,000 times @ 60 - 80 m.p.h. Increased speed to 100 m.p.h. The driving gear broke loose from the driving shaft after 10 cycles. | |

STEWART GEAR BOXES

| | | |
|---|---|---|
| #1 | 8,243 | Operating |
| #2 | 8,243 | Operating |

#3 32,124 Operating

233

DEFENDANT'S EXHIBIT 234

D 234 HT 5-16-74

SINGER

251 FIRST STREET • ELIZABETH, N. J.

MEMORANDUM

TO: Mr. C. W. Broeker - Assistant General Manager
Manufacturing Division

FROM: A. Romel

DATE: December 28, 1964 REFER TO:

SUBJECT: Endurance Testing of Sensing Unit - Part No. 17-342034

Dear Sir:

The following is a summary of endurance tests being performed on the above unit.

| Unit No. | Condition | Accumulated Mileage |
|---|---|---|
| 1 | Unit functional on Sensing Unit Test Stand | 16,939 |
| 2 | " " " " " | 7,022 |
| 3 | " " " " " | 7,022 |
| 4 | " " " " " | 7,022 |
| 5 | " " " " " | 20,311 |
| 6 | " " " " " | 7,022 |

All units were running 80 m.p.h. at room temperatures.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel

A. Romel, Manager
Manufacturing Engineering
Contract Sales

AR:ms

cc: Messrs. J. Fecko
D. A. Adams
C. Plumgis
H. Sharp

Return to Romel - G.F.D.

DEFENDANT'S EXHIBIT 236

EXHIBIT 1V
PLAINTIFF

Mr. C. W. Brocker - Assistant General Manager
Manufacturing Division

A. Romol

February 1, 1965

Endurance Testing of Sensing Unit - Part No. 17-342034

Dear Sir:

The following is a summary of endurance tests being performed on the above unit.

| UNIT NO. | CONDITION | ACCUMULATED MILEAGE |
|---|---|---|
| 1 | Unit functional on Sensing Unit Test Stand - See Note #1 | 64,179 |
| 2 | Failed - Replaced with #9 | 19,556 |
| 3 | Unit functional on Sensing Unit Test Stand | 54,264 |
| 4 | Failed - Replaced with #7 | 12,539 |
| 5 | Failed - Replaced with #8 | 25,826 |
| 6 | Failed - Replaced with #10 | 19,556 |
| 7 | Failed | 25,523 |
| 8 | Failed - Replaced with #11 | 23,367 |
| 9 | Unit functional on Sensing Unit Test Stand | 34,719 |
| 10 | Unit functional on Sensing Unit Test Stand | 34,719 |
| 11 | Unit functional on Sensing Unit Test Stand | 18,231 |

The speed has been reduced from 80 m.p.h. to 60 m.p.h. and units #1, #3, #9, #10 and #11 have been operating at this speed for the past 13,905 miles.

D-236

After viewing all available copies of the preceding page, counsel for the Appellant believes that the preceding page reads as follows:

"Mr. C. W. Broeker - Assistant General Manager
Manufacturing Division

A. Romel

February 1, 1965

Endurance Testing of Sensing Unit - Part No. 17-342034

Dear Sir:

The following is a summary of endurance tests being performed on the above unit.

| UNIT NO. | CONDITION | ACCUMULATED MILEAGE |
|---|---|---|
| 1 | Unit functional on Sensing Unit Test Stand - See Note #1 | 64,179 |
| 2 | Failed - Replaced with #9 | 19,556 |
| 3 | Unit functional on Sensing Unit Test Stand | 54,264 |
| 4 | Failed - Replaced with #7 | 12,539 |
| 5 | Failed - Replaced with #8 | 25,826 |
| 6 | Failed - Replaced with #10 | 19,556 |
| 7 | Failed | 25,523 |
| 8 | Failed - Replaced with #11 | 23,387 |
| 9 | Unit functional on Sensing Unit Test Stand | 34,719 |
| 10 | Unit functional on Sensing Unit Test Stand | 34,719 |
| 11 | Unit functional on Sensing Unit Test Stand | 18,231 |

The speed has been reduced from 80 m.p.h. to 60 m.p.h. and units #1, #3, #9, #10 and #11 have been operating at this speed for the past 13,906 miles."

Mr. C. M. Brocker - 2 - February 1, 1965

NOTE #1: This unit is attached to and driven directly by a gear box without the use of a flexible cable.

All units were running at room temperatures.

Examination of the above failures indicated the units became highly contaminated with foreign matter causing the units to short out. The thrust washer wire contact (17-342527) and reverse cam thrust washer (17-342522) wore out and sheared in 95% of the failures. The test speed of 80 m.p.h. may have been excessive for continuous running. We have therefore reduced this speed to 60 m.p.h. and will continue to test units at this speed for comparison. It should be noted that various attempts to restrain the foreign matter have been fruitless. We will continue in our efforts to solve this problem.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel, Manager
Manufacturing Engineering
Power

AR:ms

cc: Messrs. J. Fecko
R. A. Kloby
O. Plungis
H. Sharp
J. Remias

After viewing all available copies of the preceding page, counsel for the Appellant believes that the preceding page reads as follows:

"Mr. C. W. Broeker -2- February 1, 1965

NOTE #1: This unit is attached to and driven directly by a gear box without the use of a flexible cable.

All units were running at room temperatures.

Examination of the above failures indicated the units became highly contaminated with foreign matter causing the units to short out. The thrust washer wire contact (17-342527) and reverse cam thrust washer (17-342522) were out and sheared in 95% of the failures. The test speed of 80 m.p.h. may have been excessive for continuous running. We have therefore reduced this speed to 60 m.p.h. and will continue to test units at this speed for comparison. It should be noted that various attempts to restrain the foreign matter have been fruitless. We will continue in our efforts to solve this problem.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel, Manager
Manufacturing Engineering
Perma

AR:ms

cc: Messrs. J. Fecko
R. A. Kloby
G. Plungis(?)
H. Sharp
J. Remias (?)"

DEF. EX.

DEFENDANT'S EXHIBIT 242

Mr. C. W. Brocker - Assistant General Manager
Manufacturing Division

A. Romel

February 10, 1965

Endurance Testing of Sensing Unit - Part No. 17-342034

Dear Sir:

The following is a summary of endurance tests being performed on the above unit.

| UNIT NO. | CONDITION | ACCUMULATED MILEAGE |
|---|---|---|
| 1 | Unit functional on test stand. Replaced with #12-(See Note #1). | 79,322 |
| 3 | Unit functional on test stand. Replaced with #13 (See Note #1). | 69,407. |
| 9 | Unit functional on test stand. Replaced with #14 (See Note #1). | 49,852 |
| 10 | Failed. Replaced with #17 (See Note #2. | 49,852 |
| 11 | Failed. Replaced with #16 (See Note #3). | 33,374 |
| 15 | Added. (See Note #4). | Started |

All above units will operate at a speed of 60 m.p.h.

NOTE #1: Units 12, 13 and 14 are conventional sensing units taken from latest stock.

NOTE #2: Unit #17 contains a teflon washer inserted into a counterbore on the gear train cover insert.

NOTE #3: Unit #16 contains a steel insert pressed into the insert of the gear train cover with a teflon washer added as indicated by Note #2.

NOTE #4: Unit #15 contains a steel insert pressed into the insert of the gear train cover.

D-242

After viewing all available copies of the preceding page, counsel for the Appellant believes that the preceding page reads as follows:

"Mr. C. W. Broeker - Assistant General Manager
Manufacturing Division

A. Romel

February 10, 1965

Endurance Testing of Sensing Unit - Part No. 17-342034

Dear Sir:

The following is a summary of endurance tests being performed on the above unit.

| UNIT NO. | CONDITION | ACCUMULATED MILEAGE |
|---|---|---|
| 1 | Unit functional on test stand. Replaced with #12 (See Note #1). | 79,322 |
| 3 | Unit functional on test stand. Replaced with #13 (See Note #1). | 69,407 |
| 9 | Unit functional on test stand. Replaced with #14 (See Note #1). | 49,852 |
| 10 | Failed. Replaced with #17 (See Note #2). | 49,852 |
| 11 | Failed. Replaced with #16 (See Note #3). | 33,374 |
| 15 | Added. (See Note #4). | Started |

All above units will operate at a speed of 60 m.p.h.

NOTE #1: Units 12, 13 and 14 are conventional sensing units taken from latest stock.

NOTE #2: Unit #17 contains a teflon washer inserted into a counterbore on the gear train cover insert.

NOTE #3: Unit #16 contains a steel insert pressed into the insert of the gear train cover with a teflon washer added as indicated by Note #2.

NOTE #4: Unit #15 contains a steel insert pressed into the insert of the gear train cover."

Mr. C. W. Brocker - 2 - February 10, 1965

Units 3, 9, 10 and 11 showed an excessive amount of grease, graphite and other foreign matter inside the gear train cover. Unit #1 showed only a slight amount of grease, graphite and other foreign matter but this unit was not driven by flexible cable. The test to be conducted at the present time will determine if the altered units #15, 16 and 17 will alleviate the above mentioned problem.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel, Manager
Manufacturing Engineering,
Perma Anti-Skid Product Line

ARmb

cc: Messrs. J. Fecko
R. A. Kloby
C. Plungis
H. Sharp
J. Remias

After viewing all available copies of the preceding page, counsel for the Appellant believes that the preceding page reads as follows:

"Mr. C. W. Broeker -2- February 10, 1965

Units 3, 9, 10 and 11 showed an excessive amount of grease, graphite and other foreign matter inside the gear train cover. Unit #1 showed only a slight amount of grease, graphite and other foreign matter but this unit was not driven by flexible cable. The test to be conducted at the present time will determine if the altered units #15, 16 and 17 will alleviate the above mentioned problem.

Very truly yours,

GENERAL FABRICATION DIVISION

A. Romel, Manager
Manufacturing Engineering,
Perma Anti-Skid Product Line

AR:ms

cc: Messrs. J. Fecko
R. A. Kloby
G. Plungis(?)
H. Sharp
J. Remias(?)"

DEFENDANT'S EXHIBIT 313

RECEIVED
JUL 14 1955
MFG. ENG. DEPT.
39

Mr. H. Kloby
Manufacturing Manager
Anti-Skid Control Division

H. Hoojcwy

July 12, 1955

Anti-Skid Filters

The foam material used in Roma Filters is Scott Foam 504 produced by the Scott Paper Company. The specific area of this grade is 1,250 sq. ft. per cubic ft.; 65 pores per lineal inch and 97% air by volume.

Our purpose was to penetrate the foam and cover the strands with a quantity of oil sufficient to catch dust particles without restricting air flow. Singer oil, Type C, 1511, in quantities of 5%, 10% and 20% was mixed with naphtha. The filters were submerged in the solution and air blown upon removal to remove excess. The following testing was performed.

1. (a). Baked @ 160°F for 24 hours.
   (b). Test stand with Arizona dust (approx. 1/4 teaspoon) - 5% solution failed, 10% and 20% o.k.

2. (a). Baked @ 160°F for 16 hours.
   (b). Test stand with additional dust - no failure.

3. (a). Baked @ 160°F for 3 hours.
   (b). Test stand with additional dust - no failure.

4. (a). Baked @ 160°F for 4 hours plus left at ambient temperature for three days.
   (b). Test stand with additional dust - no failure.

After Test #1 the filters with 5% and 10% solution were removed from test cycle as being unacceptable. Continued testing was performed on units with 20% oil solution.

In line with the above testing consideration was given to the amount of heat under the hood of an automobile. The following is submitted for information purposes only.

1. Filter material removed from its container and placed in an oven at 325°. 16 hours shrunk approx. 25% in height and 10% in width.

D.P.E
313

[DX 313, p 2]



2. On a car trip to Auburn, New York in an 8 cyl. 1965 Chevy (330 miles) Tempilaq indicators were applied at firewall, valve covers and mid board areas. Indications of temperature = 193°F melted 199°F did not melt.

3. Tempilaq indicators were applied to the company test car (Cadillac) on all components under the hood = 193°F melted 200°F did not melt.

The Fram Corporation returned filters (Perma) which they treated with 50% oil (SAE 30) and 50% carbon-tetrachloride. They claim a filter efficiency of 99.7%.

Based on the tests performed I recommend we use a solution of 20% Mobil DTE light oil (Singer Type II) 80% 1.1.1 trichloroethane to increase the efficency of the Perma filter. Method = (1) dip in solution (2) remove excess by shaking, centrifuge or forced air. This secured with singer chemist G. Chaplenko. I would recommend this filter be changed at 5,000 miles or six months, which ever comes first.

The second Fram paper filter has been tested with the following results:

23 hours running time @ 18 cycles per minute = 24,840 cycles or approximately 4,000 panic stops with 6 pulses per stop. This unit has not failed.

Further testing on Fram filters will be performed as test stand is available.

R. Hrejsa

RH/co

cc: Messrs. C.W. Brecker
E. Sprague
J. Fecko
J. Larrousse
A. Nonel

[DX 323, p 1]

DEFENDANT'S EXHIBIT 323

PR

Effect of Low Temperature

on

.030/.032" Dia. Metering Valve

#323

EG 5501B/64

# MEMORANDUM

SINGER

321 FIRST STREET · ELIZABETH, N.J.

TO: Mr. A. Romel - Manager - Manufacturing Engineering
Anti-Skid Control

FROM: P. Urban

DATE: December 1, 1965

REFER TO:

SUBJECT: Effect of Low Temperature on the Pressure Differential Across a .030/.032" Diameter Metering Valve

A complete report on the above subject is attached. As indicated in the report, a decrease in temperature will increase the pressure differential across the valve. If the temperature of the hydraulic fluid is below 0°F., the unit would fail to cycle on snow covered roads. To assure that the unit would cycle in temperatures down to -40°F., we would have to increase the orifice diameter to .033".

Paul Urban

P. Urban
Mechanical Engineer

PU:ms

Att.

December 1, 1965

Engineering Study of the Effect of Temperature on the Differential Pressure Across a .030/.032" Diameter Orifice Metering Valve

Background Information

A metering valve with an orifice diameter of .031" was required in the hydraulic brake line of automobiles with a single piston master cylinder. The metering valve was placed between the vacuum container and the brake block, so that there would be unrestricted fluid flow when the brake pedal was being depressed and a restricted flow when the brake pedal was being released.

The desired effect was to delay the release of hydraulic brake pressure during the wheel release portion of the hydraulic cycling created by the anti-skid system. Many different size orifices were tested on both wet and dry surfaces. The test results showed a general improvement in stopping distance on all road conditions as the orifice diameter was decreased. The minimum orifice diameter was found to be .028" for a smooth wet concrete road; smaller orifices were found to prevent the wheels from unlocking on this surface. A "safety factor" of .003" in orifice were manufactured to a .030/.032" diameter and tested on both wet and dry surfaces. The results from these tests were satisfactory.

## Effect of a Metering Valve on the Hydraulic Cycling Caused by the Anti-Skid System

A metering valve installed in the brake line, as noted above, will tend to restrict fluid flow as the hydraulic piston in the vacuum container moves to release hydraulic pressure in the brake line. The flow rate of brake fluid during the pressure release portion of the cycle is dependent on piston movement and can be considered a constant for any individual cycle regardless of orifice size, fluid temperature, fluid pressure, and fluid density, as long as the hydraulic pressure in the piston cylinder does not become negative. Negative pressure is not possible whenever the hydraulic pressure drops below a predetermined setting (90 p.s.i.).

Considering the flow rate (Q) a constant in the following formula (for fluid flow through an orifice in a pipe)

$$Q = CAo\sqrt{\frac{2\,\Delta P}{\rho}}$$

for any given temperature, the discharge coefficient (C) and the fluid density ($\rho$) will be constant. Therefore, the pressure differential ($\Delta P$) will vary inversely with the square of the orifice area (Ao). That is, as the orifice is reduced in diameter, the pressure differential will be increased.

There is a maximum pressure differential allowable for each

type of road and surface condition. Should the pressure differential become larger than the maximum allowable, wheel release after initial lock-up would be impossible. To explain this concept of a maximum pressure differential, we shall use the following illustration: A vehicle equipped with an anti-skid system and a metering valve is driven at 30 m.p.h. on a wet concrete road. The driver then brakes the vehicle hard causing all wheels to lock. The Sensing Unit will react to the locked wheel condition by applying vacuum to the piston diaphragm. This, in turn, will cause the piston to move, thereby releasing hydraulic pressure. As the piston moves, the hydraulic pressure in the brake line will decrease as fluid starts to flow from the brakes through the metering valve and into the hydraulic cylinder. The pressure on the cylinder side of the valve will decrease at a faster rate than the pressure on the brake side because, the valve orifice will tend to restrict flow causing a pressure drop across the valve. Should the pressure on the cylinder side of the valve drop below the Pressure Switch setting (90 p.s.i.) before the pressure on the brake shoes was low enough to release the wheels, the Pressure Switch would open and full braking pressure would be applied to the brake shoes. When the Pressure Switch opens, the electro-magnet is released, closing the rotary valve. To open the rotary valve (release hydraulic pressure) the micro-switch circuit must be triggered. Wheel rotation, hydraulic pressure

in excess of the pressure switch setting (90 p.s.i.), and wheel lock-up are required in sequence to trigger the micro-switch circuit. Because the wheels remained in a locked condition, the micro-switch circuit would not be triggered and the vehicle would skid to a stop.

As long as the maximum allowable pressure differential for each road and surface condition is not exceeded, the only noticeable effect that the metering valve will have on cycling, is to limit the release of hydraulic pressure.

## Effect of Temperature on the Pressure Differential Across a Metering Valve

As the temperature is decreased, the discharge coefficient (C) will decrease and the fluid density ($\rho$) will increase. The net result being an increase in the pressure differential across the metering valve for a given flow rate. The pressure differential across a .030/.032" metering valve will surpass the critical value on snow covered roads at approximately zero degrees fahrenheit (0°F.). (See Figure 6). This would cause a locked wheel skid.

Therefore, the use of a metering valve with an orifice of .030/.032" would be extremely dangerous and not recommended. There is a possibility that a larger orifice would work satisfactorily even at lower temperatures. Calculations show that an .033" diameter orifice would work down to -40°F.

## Discussion of Method used to Determine Differential Pressures at Various Temperatures

The differential pressure ($\Delta P$) across a metering valve is a function of the following: (1) flow rate, Q; (2) coefficient of discharge, C; (3) fluid density, $\rho$; and orifice area, Ao.

The above are related in the following formula

$$Q = CAo \sqrt{\frac{2 \Delta P}{\rho}}$$

The flow rate (Q) is dependent upon the manifold vacuum moving the hydraulic piston against the force of the vacuum container spring. The fluid density ($\rho$) is a function of temperature and the discharge coefficient (C) is a function of the ratio of the orifice to pipe area and temperature. We shall assume that during any cycle, the piston movement (during the pressure release phase) is at a constant velocity. Therefore, the fluid flow will also be a constant. With the fluid flow (Q) and the orifice area (Ao) being constants in the above equation, the value of pressure differential ($\Delta P$) will be a function of discharge coefficient (C) and density ($\rho$), which are functions of temperature and area. Therefore, the pressure differential will be a function of temperature and orifice area.

The discharge coefficient (C) will decrease as the temperature decreases and the area (Ao) remains constant. The fluid

density ($\rho$) will increase as the fluid temperature decreases. It is easily seen in the above equation that in order to maintain a constant fluid flow as the fluid temperature decreases, the pressure differential ($\Delta P$) must increase. As previously mentioned, the amount of pressure differential is critical; too much and the wheels will not release after lock-up, too little and vehicle stopping distance will increase. We can determine the maximum rate of fluid flow for an .030/.032" orifice diameter by measuring the differential pressure drop and temperature in a test vehicle, setting these parameters on the testing apparatus shown in Figure 1, and measuring fluid flow. The fluid density can be calculated and then the coefficient of discharge can be determined. The discharge coefficient for any other temperature can be found in a similar manner. Figure 2 is a plot of discharge coefficient versus temperature for an .030/.032" orifice diameter. Now that we know the coefficient of discharge for the orifice, we can compute the maximum pressure differential possible for any temperature. Figure 3 is a plot of the differential pressure versus temperature with maximum pressure differentials for dry and snow covered roads. These critical pressure differentials were calculated by knowing that at 120°F. fluid temperature, an .025" diameter orifice would not release wheels on dry surfaces, and an .028" diameter orifice would sometimes release the wheels, and would not at other times, on a smooth wet concrete surface.

Assuming that the wet concrete surface approximates a snow covered road, the critical pressures for both dry and snow covered roads were calculated. Where these critical pressure differentials cross the plot of the pressure differential for an .030/.032" orifice diameter, mark the temperatures at which wheel release would become impossible for the road conditions noted.

It should be noted, that in order to determine discharge coefficients at low temperatures (-40°F.), SAE 50 oil was used in the test apparatus and readings were taken at an equivalent viscosity level of brake fluid at -40°F.

Determine the Density ($\rho$) of Ucon Industrial Brake Fluid

Known: Sp. Gr. measurements made by R. Robitzski Dept. 14

| Temperature °F | Sp. Gr. = S |
|---|---|
| 115° | 1.016 |
| 79° | 1.030 |
| 52° | 1.051 |
| 30° | 1.060 |
| 20 | 1.064 |

This data when plotted form a straight line, so we will therefore assume the following equation:

Sp. Gr. = $S = 1.073 - .00062\,T$ with T in °F

Density $\rho$ $\quad \rho = .934(10^{-5})S$ in $\frac{\#\text{-sec}^2}{\text{in}^4}$

| | S | $\rho$ | $\frac{\#\text{-sec}^2}{\text{in}^4}$ |
|---|---|---|---|
| 40°F | 1.103 | $\rho$ = .000103 | |
| 0°F | 1.078 | $\rho$ = .0001005 | |
| 40°F | 1.053 | $\rho$ = .0000983 | |
| 80°F | 1.028 | $\rho$ = .0000959 | |
| 120°F | 1.03 | $\rho$ = .0000937 | |

Determine the Density (ρ) of SAE 50 Non-Detergent Oil at 120° F

Known API° = 27.1 @ 0°F

27.8 @ 60°F

28.3 @ 100°F

$$\therefore API^\circ_x = \left(\frac{API_{100} - API_0}{T_{100} - T_0}\right) T_x + C$$

$$= \left(\frac{28.3 - 27.1}{560 - 460}\right) T_x + C$$

$$= .012\, T_x + C$$

let $T_x = 100$

$API_x = 28.3 = .012\,(560) + C$

$C = 21.6$

let $T_x = 0$

$API_x = .012\,(460) + 21.6 = 27.1$ ✓

$\therefore API_x = .012\, T_x + 21.6$ where $T_x$ is in °Rankin

$API_{10} = .012\,(460+10) + 21.6 = 6.6 + 21.6 = 28.20$

$API_{120} = .012\,(460+120) + 21.6 = 6.96 + 21.6 = 28.56$

$API_{116} = .012\,(576) + 21.6 = 6.91 + 21.6 = 28.51$

S = Specific Gravity in #/unit vol./#/unit vol $H_2O$ @ 60°F

$\rho$ = density in slugs/ft³ or $\frac{\#\text{-sec}^2}{in^4}$

$\rho = S\ 62.4/g.1728 = 1.937\ S$

$\therefore \rho = .00112\ S$

$S = \frac{141.5}{131.5 + API°}$

at 90°F $S = \frac{141.5}{131.5 + 28.20} = .886$ $\therefore \rho = (.886).00112 = .000993$

at 120°F $S = \frac{141.5}{131.5 + 22.56} = .881$ $\rho = (.881).00112 = .000987$

at 116°F $S = \frac{141.5}{131.5 + 23.51} = .883$ $\rho = (.883).00112 = .000990$

Determine the discharge coefficient (c) for varying temperature

$Q = CA\sqrt{\frac{2\Delta P}{\rho}}$ eq# 9-27 Pg. 320 FLUID MECHANICS, 2nd Ed. by V.L. Streeter

$C = \frac{Q}{A\sqrt{\frac{2\Delta P}{\rho}}}$ holding $\Delta P$ & $A$ constant we have,

for -40°F $Q = .73\ in^3/sec$, $\Delta P = 175\ psi$, $\rho = .000103$, $A = .000754\ in^2$

$$C = \frac{.73}{.000754\sqrt{\frac{2(175)}{.000103}}}$$

$$= \frac{.73}{7.54(.1343)}$$

$$= .526$$

for 0°F $Q = .86$, $\rho = .0001005$

$$C = \frac{.86}{7.54(.1866)}$$

$$C = .612$$

for 40°F $Q = .94$, $\rho = .0000933$

$$C = \frac{.94}{7.54(.1332)}$$

$$C = .663$$

for 80°F  Q = 1.08  ρ = .0000958

$$C = \frac{1.00}{7.54(.1910)}$$

C = .694

for 170°F  Q = 1.04  ρ = .0000937

$$C = \frac{1.04}{7.54(.1930)}$$

C = .715

Calculate Pressure Differentials at 120°F, 80°F, 40°F, 0°F & -40°F for an .030/.032 Metering Valve, w/ Q = 1.04 in³/sec

Given: $Q$ = cons't = 1.04 in³/sec
$A$ = .000754 in²

for 120°F $\rho = .937(10^{-4})$, $C = .715$

$$\Delta P = \frac{\rho}{2}\left(\frac{Q}{CA}\right)^2$$

$$= \frac{.937(10^{-4})}{2}\left(\frac{1.04}{.715(7.54)(10^{-4})}\right)^2$$

$$= (.4685)(10^{-4})\ (.0373)(10^{8})$$

$$= 175 \text{ psi}$$

for 80°F $\rho = .959(10^{-4})$, $C = .694$

$$\Delta P = \frac{.959(10^{-4})}{2}\left(\frac{1.04}{.694\ 7.54(10^{-4})}\right)^2$$

$$= (.4795)(10^{-4})\ (.0397)\ (10^{8})$$

$$= .191 \text{ psi}$$

for 40°F $\rho = .983(10^{-4})$, $C = .663$

$$\Delta P = \frac{.983(10^{-4})}{2}\left(\frac{1.04}{.663\ 7.54(10^{-4})}\right)^2$$

$$= (.4915)(10^{-4})\ (.0433)\ (10^{8})$$

$$= 213 \text{ psi}$$

for 0°F $C = 1.005\ (10^{-4})$, $C = .612$

$$\Delta P = \frac{1.005\ (10^{-4})}{2}\left(\frac{1.04}{.612\ (7.54)(10^{-4})}\right)^2$$

$$= .50025(10^{-4})\ (.0510)\ (10^8)$$

$$= 255 \text{ psi}$$

for -40°F $C = 1.03(10^{-4})$, $C = .526$

$$\Delta P = \frac{1.03(10^{-4})}{2}\left(\frac{1.04}{.526\ 7.54\ (10^{-4})}\right)^2$$

$$= 1.5015)(10^{-4})\ (.0438)\ (10^8)$$

$$= 345 \text{ psi}$$

Calculate Critical Pressure Differential ($\Delta P_c$)

Known: A .025" dia. orifice does not release wheels on ~~slippery~~ DRY surfaces. Therefore, the pressure differential ($\Delta P$) is a critical value.

$A = .000491\ in^2$

Assume: the coefficient of discharge is 3% larger than for an .030/.032 value. $\therefore C_c = 1.03\ C_c$

① $T = 120°F$ $\rho = .937\ (10^{-4})$ $C_c = .734$ $Q = 1.04$

$$\Delta P_c = \frac{\rho}{2}\left(\frac{Q}{CA}\right)^2 = \frac{.934\ (10^{-4})}{2}\left(\frac{1.04}{(.734)\ 4.91\ (10^{-4})}\right)^2$$

$$= .467\ (10^{-4})\ .0835\ (10^8)$$

$$= 390\ psi$$

Calculate Pressure Differential for an .028" dia. orifice at a flow rate $Q = 1.04$ in³/sec

for $T = 120°F$ $\rho = .937\ (10^{-4})$ assume $C_3 = C_1 = .713$

$$\Delta P = \frac{.937(10^{-4})}{2}\left(\frac{1.04}{.713\,(6.16)(10^{-4})}\right)$$

$$= (.4685)(10^{-4})\,(.0561)(10^{8})$$

$$= 263 \text{ psi}$$

CALCULATION OF ORIFICE DIA. REQUIRED TO REDUCE OPERATING TEMPERATURE FROM 0°F. TO -40°F.

Assume Coeficient of Discharge for new orifice = .031" orifi

$\Delta P_1$ @ °F. for .031" orifice dia. = 263 psi

$$\Delta P = \frac{\rho}{2}\left(\frac{Q}{CA}\right)^2$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{A_1^2}{A_2^2}$$

$$A_2^2 = A_1^2 \frac{\Delta P_2}{\Delta P_1}$$

$$A_2 = A_1\sqrt{\frac{\Delta P_2}{\Delta P_1}}$$

$\Delta P_2 = 350$ psi $A_1 = .0754$ in$^2$

$$A_2 = .0754\sqrt{\frac{350}{263}}$$

$A_2 = .0869$ in$^2$

$D_2 = .033$ in.

(.025 dia)

Calculation of Flow Rate at various differential pressures and temperatures

① ΔP = 175 psi ; T = 100°F Q = .66 in³/sec

T = 120°F Q = .675

T = 140°F Q = .68

② ΔP = 200 psi ; T = 100°F Q = $Q_{175}\sqrt{\frac{200}{175}}$ = .705 in³/sec

T = 120 Q = .721

T = 140 Q = .727

③ ΔP = 225 ; T = 100 Q = .749

T = 120 Q = .766

T = 140 Q = .771

④ ΔP = 250 ; T = 100 Q = .789

T = 120 Q = .807

T = 140 Q = .814

⑤ ΔP = 275 ; T = 100 Q = .828

T = 120 Q = .846

T = 140 Q = .852

⑥ ΔP = 300 T = 100 Q = .865

T = 120 Q = .885

T = 140 Q = .890

The American Society for Testing Materials has developed an empirical method for expressing the variation of viscosity of petroleum products with temperature. These relationships have been set up in the form of charts. These charts are very convenient, provide sufficient accuracy for all practical purposes, and are now widely recog-

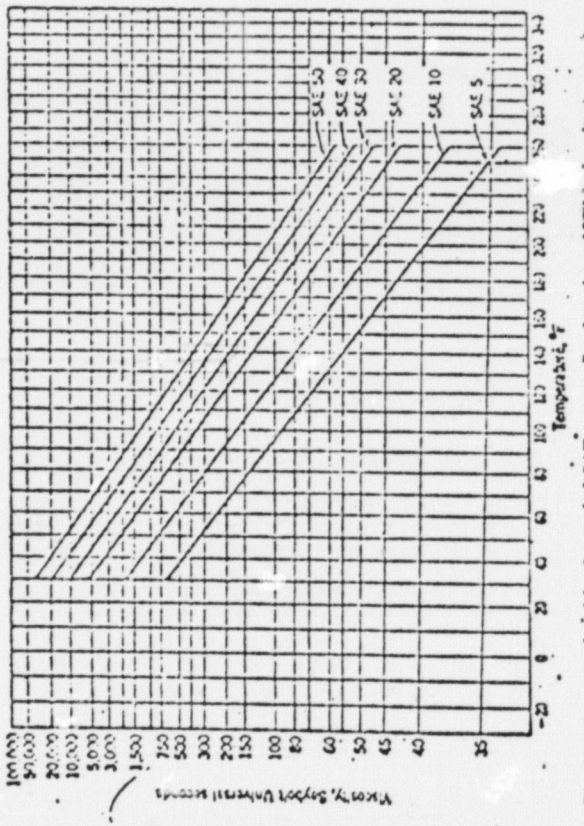



Fig. 26. Average viscosities for typical SAE motor oils plotted on ASTM viscosity-temperature chart.

nized and accepted. They are based upon an assumed equation that agrees very well with the results of tests on viscosity. This equation



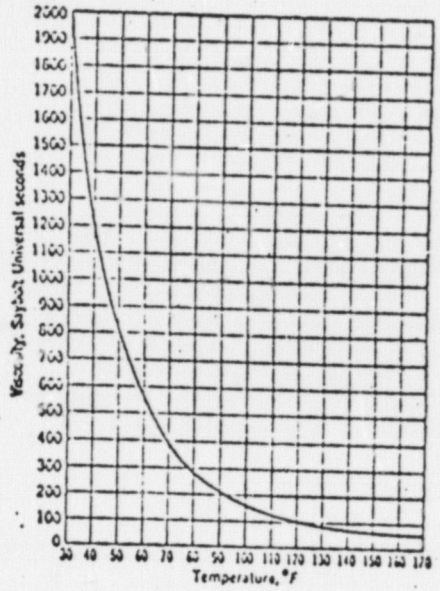



Fig. 27. Viscosity-temperature relationship for an SAE 10 oil, plotted on Cartesian coordinates.

gives a straight-line graph, when a function of viscosity is plotted against a function of temperature. The equation is:

$$\log_{10} \log_{10} (\nu + 0.8) = n \log_{10} T + C \qquad (24$$

where $\nu$ is the kinematic viscosity in centistokes, $T$ is the absolute temperature in degrees Rankin, and $n$ and $C$ are constants for any given oil.

The resulting graph is a straight line. If the viscosities of any oil are known at two temperatures, its viscosity at any third temperature can be found directly from such a graph. Figure 26 shows such a graph. Notice that the straight line representing SAE 10 is considerably different from the same data plotted on Cartesian coordinates in Fig. 27. The straight lines on these special coordinates, as in Fig. 26, should not be allowed to disguise the fact that there is a very

E-1130
[DX 323, p 22]
[DX 323, p 22]

E-1131

[DX 329, p 23]



## Viscosity Scale

To assist in making the concept of viscosity more real and physical it is suggested that a viscosity scale be set up with the range extending from water at the low viscosity end of the scale to, say, castor oil at the upper. This can easily be done with a series of 6- or 8-ounce stoppered bottles and some gummed labels. In the first bottle place some water. The viscosity of water at 70°F is almost exactly 1.0 centipoise. Next a bottle of turpentine with a viscosity of about 1.5 centipoises. Next SAE 10 motor oil with a viscosity of approximately 70 centipoises. Olive oil is next with a viscosity of about 100 centipoises at room temperature. Next a medium motor oil SAE 30 with a viscosity of about 300 centipoises. Glycerine represents a liquid with a viscosity of about 500 centipoises. Next a heavy motor oil SAE 50 with a viscosity of about 800 centipoises. Honey could be the next sample with about 1500 centipoises. And lastly, castor oil with a viscosity of some 2000 or more centipoises. A list of typical fluid viscosities is shown in Table 1.

**Table 1. Typical Fluid Viscosities at 70°F**

| Fluid | Centipoises | Reyns | Microreyns |
|---|---|---|---|
| Honey (approx.) | 1500 | $2175 \times 10^{-7}$ | 217.5 |
| SAE 50 (heavy) | 800 | $1160 \times 10^{-7}$ | 116 |
| Glycerine | 500 | $725 \times 10^{-7}$ | 72.5 |
| SAE 30 (medium) | 300 | $435 \times 10^{-7}$ | 43.5 |
| Olive oil | 100 | $145 \times 10^{-7}$ | 14.5 |
| SAE 10 (light) | 70 | $101 \times 10^{-7}$ | 10.1 |
| SAE 5 (X light) | 32 | $46.5 \times 10^{-7}$ | 4.65 |
| Ethylene glycol | 20 | $29 \times 10^{-7}$ | 2.9 |
| Mercury | 1.5 | $2.17 \times 10^{-7}$ | 0.217 |
| Turpentine | 1.45 | $2.1 \times 10^{-7}$ | 0.21 |
| Water | 1.00 | $1.45 \times 10^{-7}$ | 0.145 |
| Octane | 0.54 | $0.78 \times 10^{-7}$ | 0.078 |
| Air | 0.018 | $0.020 \times 10^{-7}$ | 0.0020 |

It is interesting to observe that the SAE 50 represents a typical oil for a reciprocating aircraft engine or perhaps for a heavy-duty truck engine. The actual viscosity at operating temperature, however, is very much less than the sample of SAE 50 would indicate at room temperature. When engine bearing temperatures reach 250 to 260°F, the oil's viscosity would be cut down from 800 centipoises to about 7 centipoises, which is not very much more viscous than water at room temperature. It is rather startling to contemplate that in an engine



bearing such a low-viscosity oil film does carry tremendous pressures. Design pressures of 2000–3000 psi are not uncommon. These design pressures are based on the average projected area of the bearing, whereas the actual unit pressures in the oil film are much higher than this—they may reach 10,000-12,000 psi or higher.

## Flow of Viscous Liquid through a Slot

Now let us derive a very fundamental equation in lubrication, that for the flow of a viscous liquid through a wide, rectangular slot. This equation will then be applied to the design of the load-supporting system

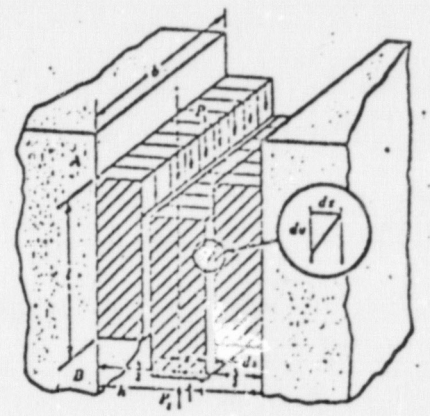
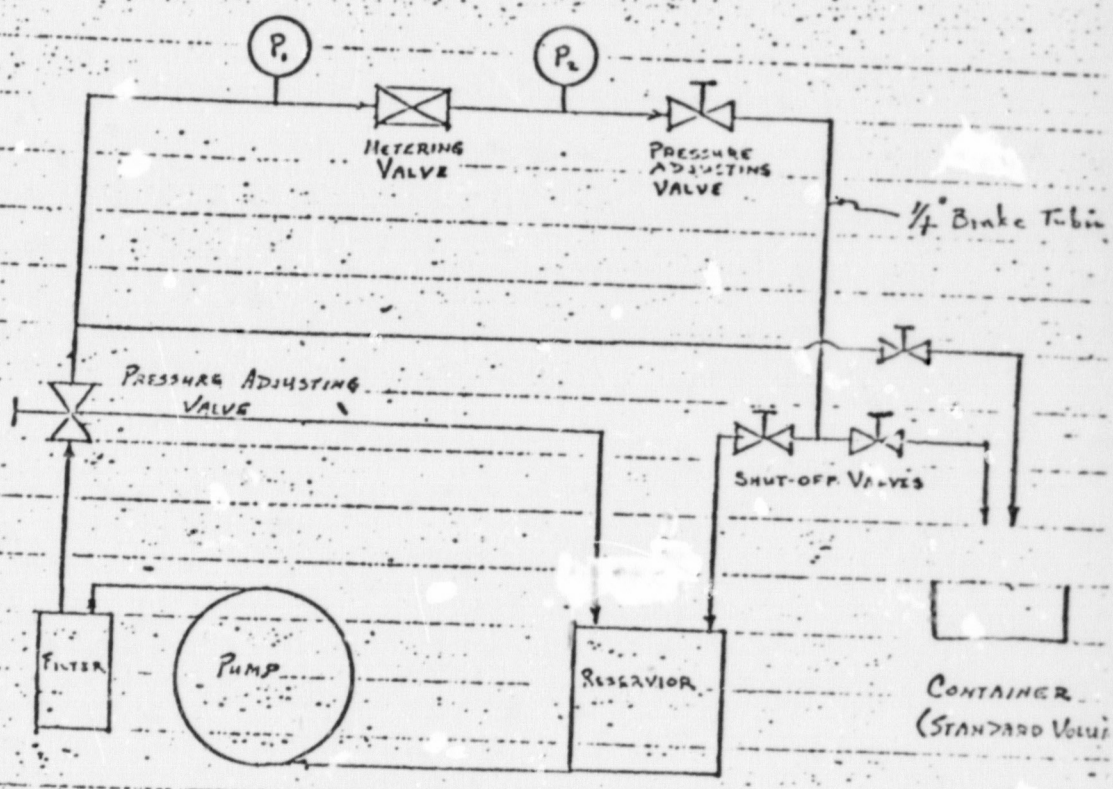



Fig. 4. Diagram showing how small element of oil film is extruded by pressure difference acting upon it.

tem of the Hale telescope at Mount Palomar, the world's largest telescope.

Consider a slot of width $b$, and length in the direction of flow $l$. The thickness of the slot is $h$. The width $b$ is assumed to be very large as compared to the film thickness $h$ so that the losses at the ends of the slot can be neglected. The length $l$ of the slot is also large so that entrance and exit losses can also be ignored. A pressure difference between the points $A$ and $B$ causes flow, Fig. 4. With $A$ being at a higher pressure than $B$, flow will be in the direction indicated.

[DX 323, p 23]




SKEMATIC OF EXPERIMENTAL SET-UP TO MEASURE FLOW RATE THROUGH A METERING VALVE

FIG. 1

K·E 10 X 10 TO ½ INCH 46 1320
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

DISCHARGE COEFICIENT VS TEMPERATURE
FOR A .030/.032" METERING VALVE
WITH ¼" PIPING

DATE 10/7/65
ENGR. P. URBAN

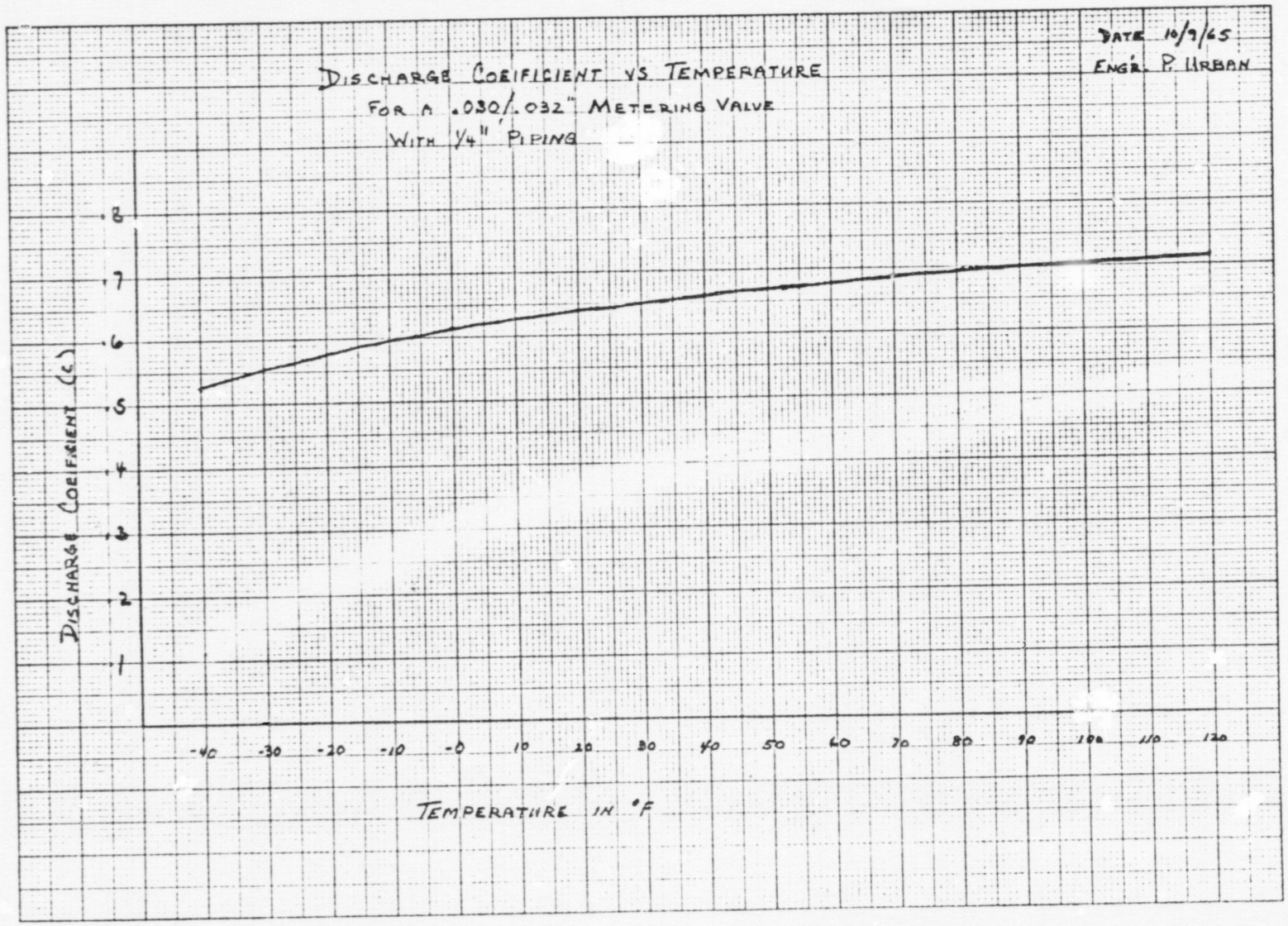



FIG # 2

E-1133

[DX 323, P 25]

[DX 323, P 25]

K-E 10 X 10 TO ½ INCH 46 1320
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

Date 10/12/65
Eng'r. P. Urban

DIFFERENTIAL PRESSURE (ACROSS .030/.032 METERING VALVE)
VARIATION WITH TEMPERATURE FOR FLOW RATE Q = 1.04 in³/sec.

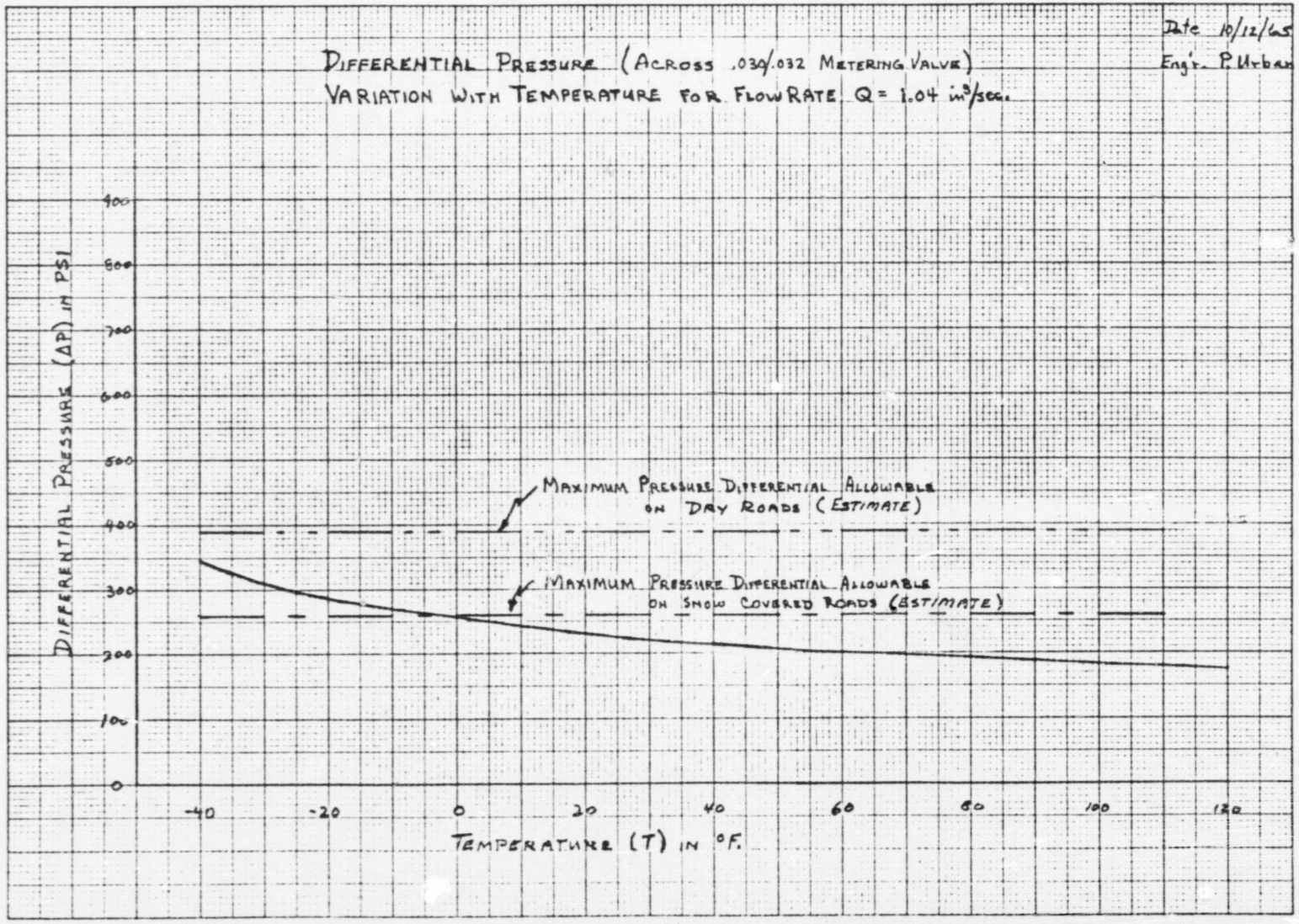



FIG. # 3

E-1134

[DX 323, p 26]

[DX 323, p 26]

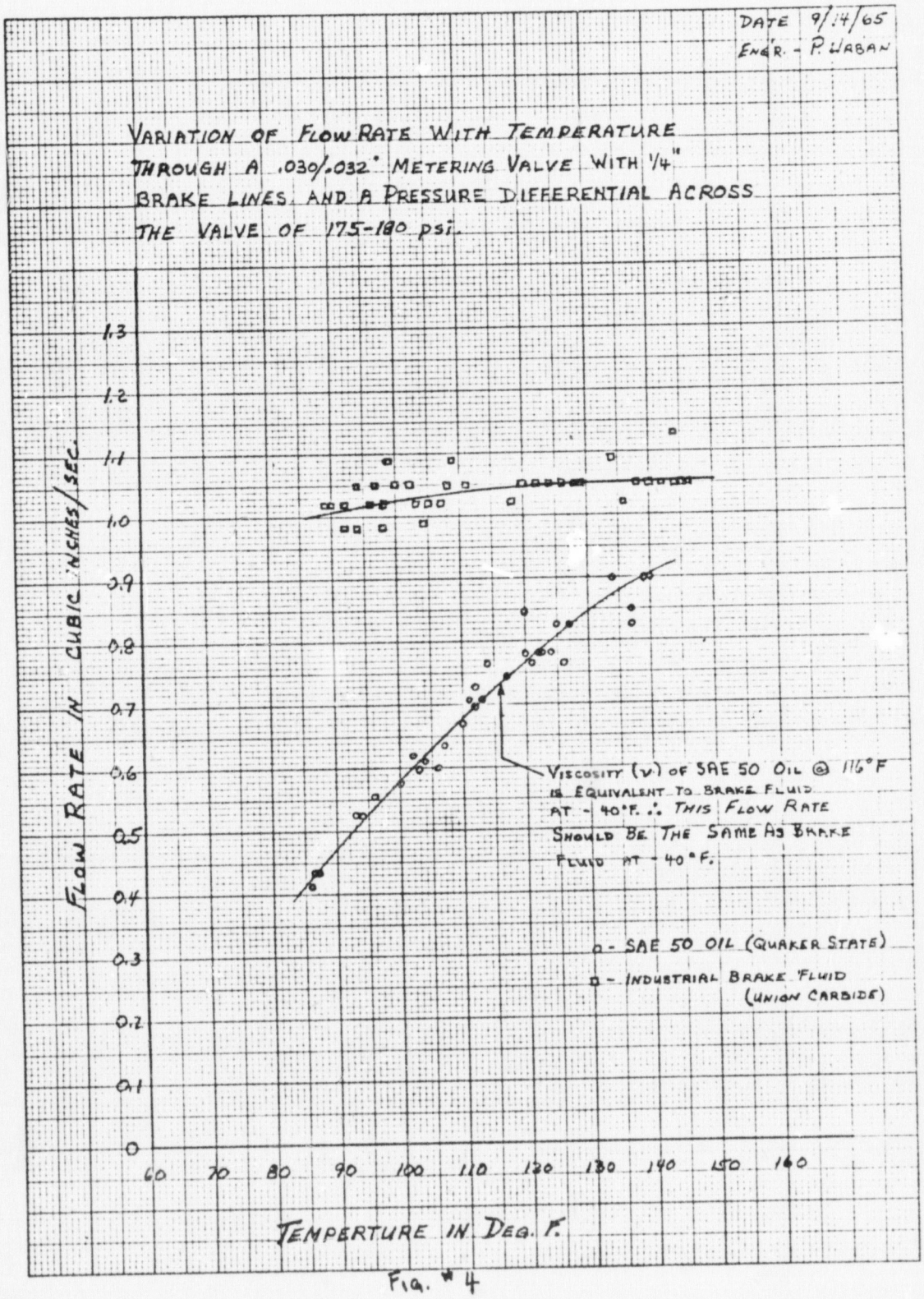

DATE 9/14/65
ENG'R. - P. WABAN
VARIATION OF FLOW RATE WITH TEMPERATURE THROUGH A .030/.032" METERING VALVE WITH 1/4" BRAKE LINES AND A PRESSURE DIFFERENTIAL ACROSS THE VALVE OF 175-180 psi.
FLOW RATE IN CUBIC INCHES/SEC.
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
60
70
80
90
100
110
120
130
140
150
160
TEMPERTURE IN DEG. F.
VISCOSITY (v) OF SAE 50 OIL @ 116°F IS EQUIVALENT TO BRAKE FLUID AT -40°F. ∴ THIS FLOW RATE SHOULD BE THE SAME AS BRAKE FLUID AT -40°F.
o - SAE 50 OIL (QUAKER STATE)
□ - INDUSTRIAL BRAKE FLUID (UNION CARBIDE)

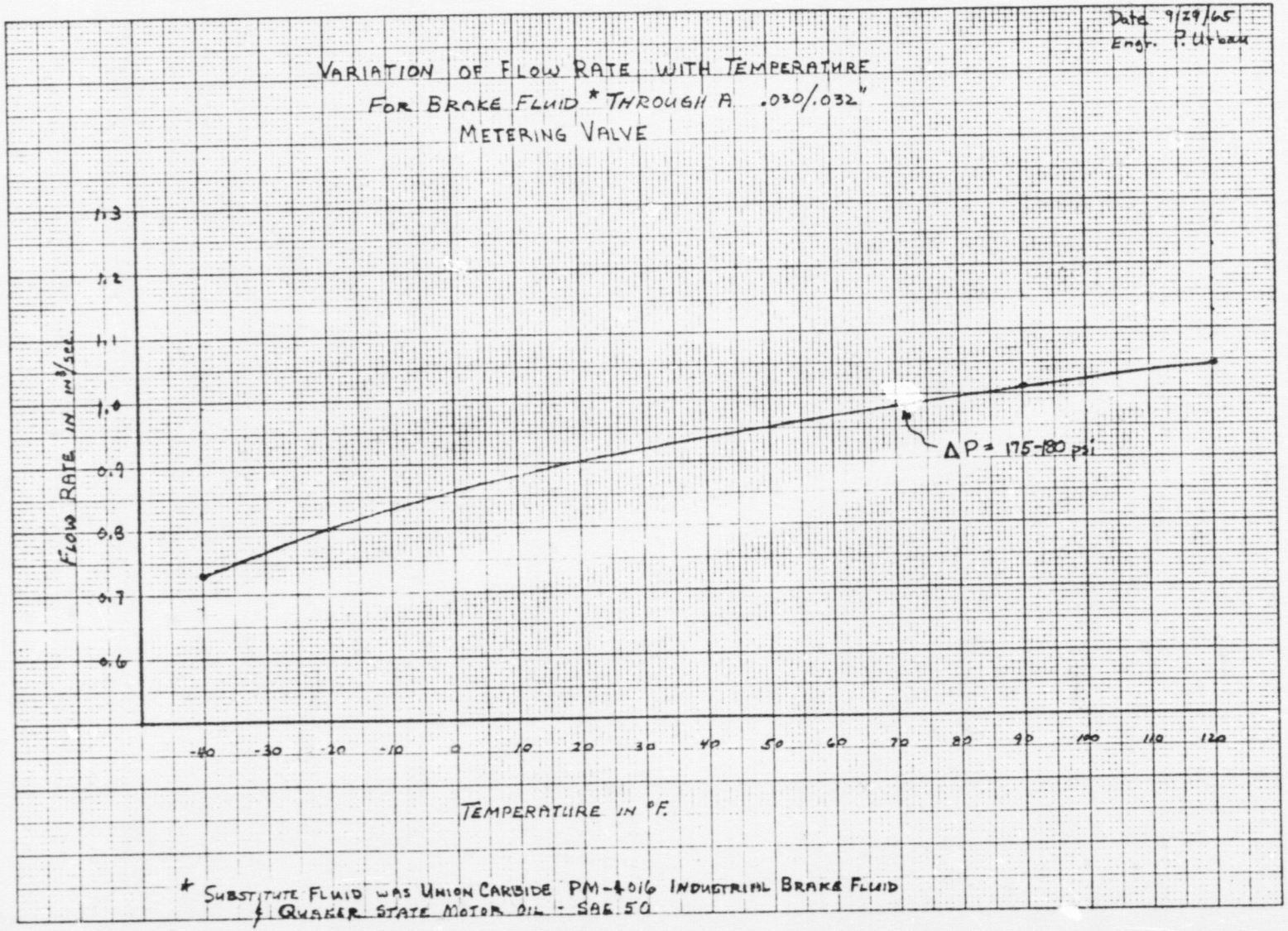
Fig. # 4

K•E 10 X 10 TO ½ INCH 46 1320
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO



Date 9/29/65
Engr. P. Urbank

# VARIATION OF FLOW RATE WITH TEMPERATURE FOR BRAKE FLUID * THROUGH A .030/.032" METERING VALVE




* SUBSTITUTE FLUID WAS UNION CARBIDE PM-4016 INDUSTRIAL BRAKE FLUID & QUAKER STATE MOTOR OIL - SAE 50

FIG # 5

E-1136

[DX 323, P 28]

[DX 323, P 28]

K&E 10 X 10 TO ½ INCH 46 1320
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

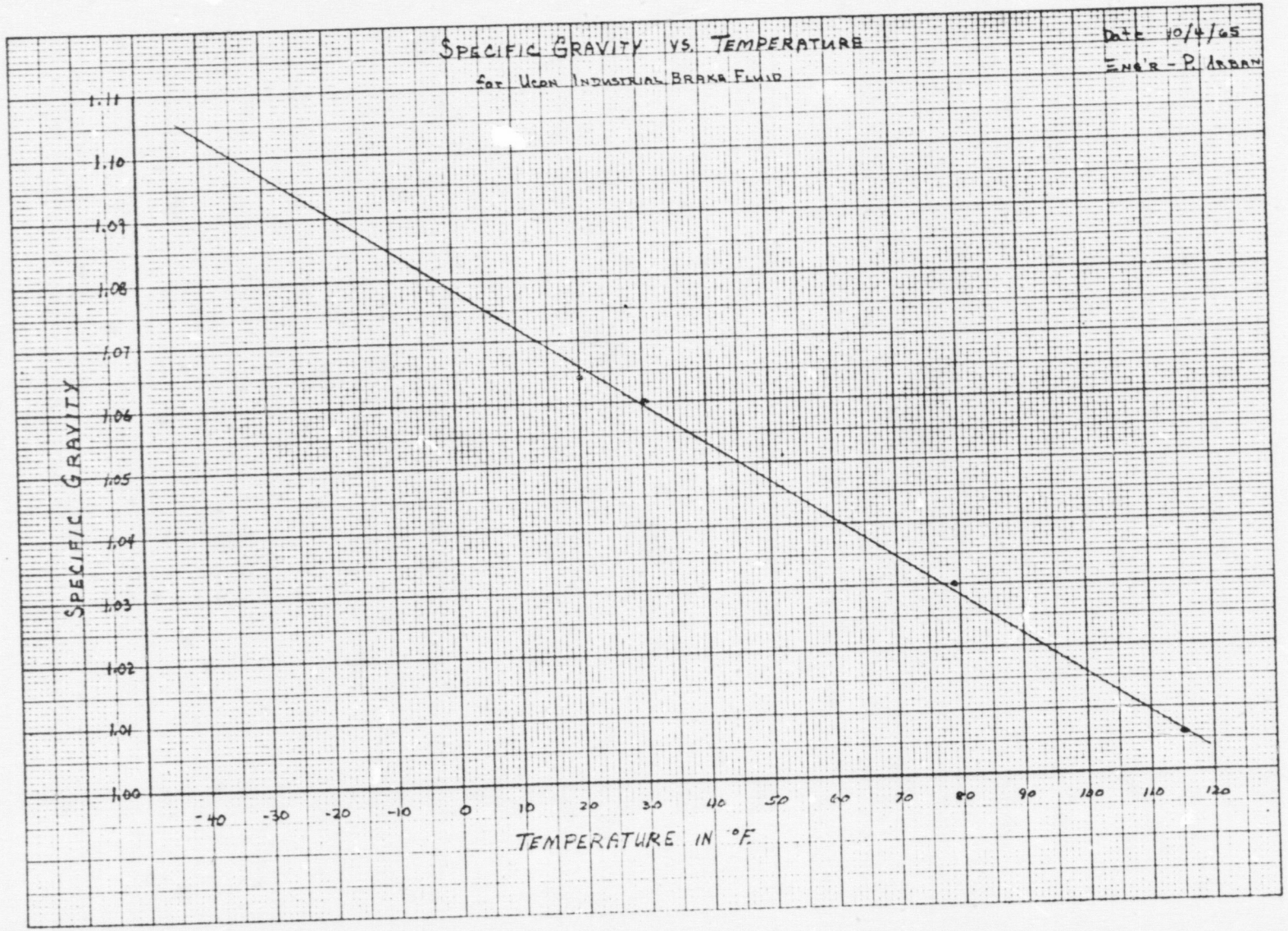



FIG. # 6

E-1137

[DX 323, p 29]

[DX 323, p 29]

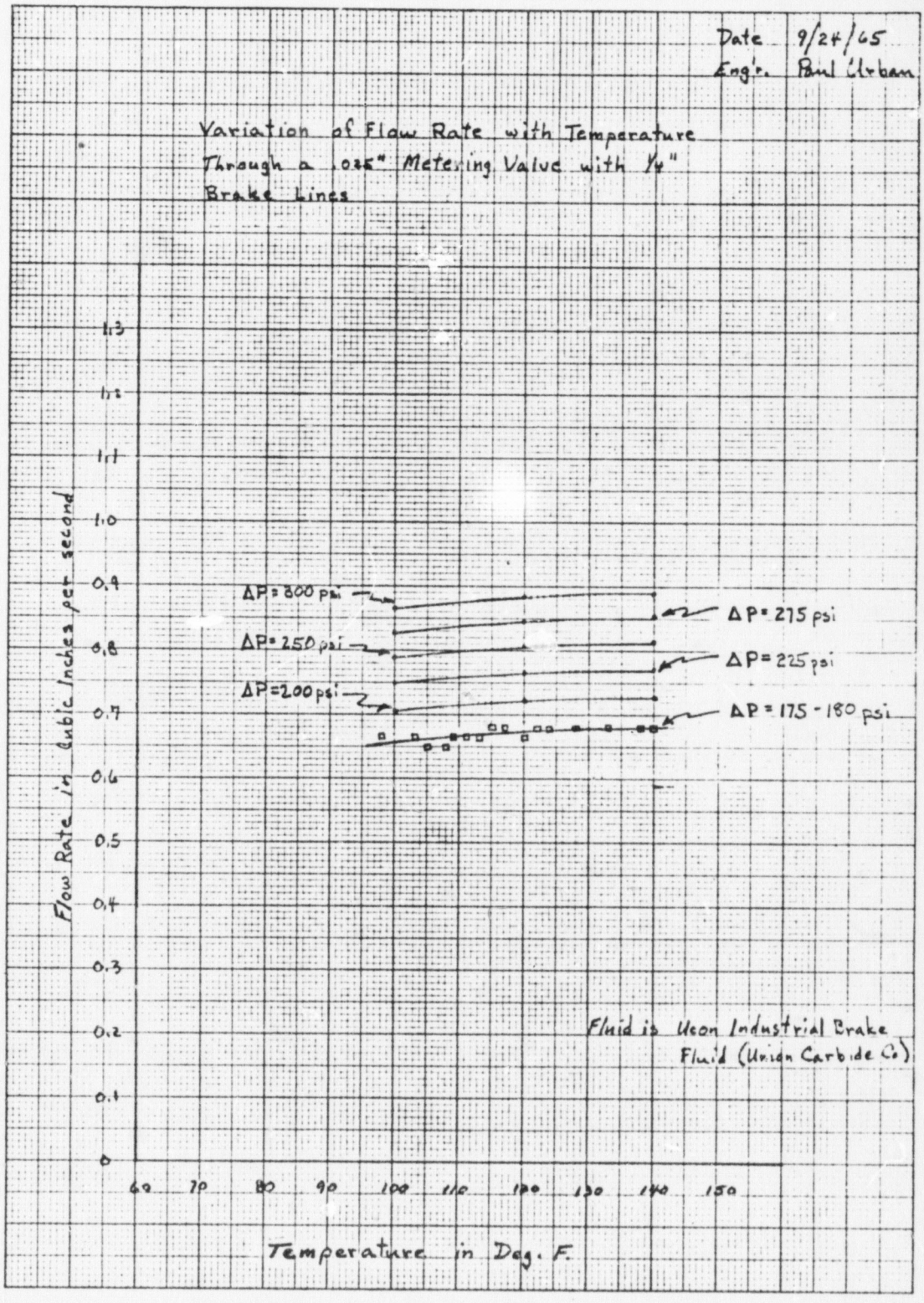

Date 9/24/65
Engr. Paul Urban
Variation of Flow Rate with Temperature Through a .035" Metering Valve with ¼" Brake Lines
Flow Rate in Cubic Inches per second
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ΔP = 300 psi
ΔP = 250 psi
ΔP = 200 psi
ΔP = 275 psi
ΔP = 225 psi
ΔP = 175 - 180 psi
Fluid is Ucon Industrial Brake Fluid (Union Carbide Co.)
60
70
80
90
100
110
120
130
140
150
Temperature in Deg. F.

Fig. # 7

FORM 64-1039

SHEET 1 OF 3

DATE 8/27/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION FLOW RATE OF HYDRAULIC BRAKE FLUID*
THROUGH A .030"/.032" METERING VALVE w/ 1/4" Brake Lines

| RUN NO. | FLUID PRESSURE $P_1$ psi | $P_2$ psi | $\Delta P$ | TIME $t$ sec. | TEMPERATURE $T$ °F | | FLOW RATE $Q$ ml./sec. |
|---|---|---|---|---|---|---|---|
| 1 | 510 | 340 | | 142 | 108° | .215 | 3.52 |
| 2 | 500 | 320 | | 143 | 112 | .213 | 3.49 |
| 3 | 500 | 320 | | 101 | 117 | .230 | 4.95 |
| 4 | 500 | 320 | | 107 | 130 | .280 | 4.65 |
| 5 | 500 | 320 | 180 | 30 | 156 | 1.020 | 16.7 |
| 6 | 500 | 320 | 180 | 31 | ? | | 16.1 |
| 7 | 500 | 320 | 180 | 29 | 142 | 1.050 | 17.2 |
| 8 | 450 | 320 | 130 | 31 | 142 | .954 | 16.1 |
| 9 | 450 | 320 | 130 | 30 | 143 | 1.020 | 16.7 |
| 10 | 450 | 280 | 170 | 27 | 144 | 1.130 | 18.5 |

REMARKS: * Union Carbide Chemical Company - Ucon Brake Fluid FM-7016

$P_1$ is the fluid pressure entering the metering valve

$P_2$ is the fluid pressure leaving the metering valve

$t$ is the time required to fill a 500 ml flask

T is the fluid temperture in the 500 ml flask

FORM 64-1039

SHEET 2 OF 3

DATE 8/30/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION FLOW RATE OF HYDRAULIC BRAKE FLUID*
THROUGH A .030/.032" METERING VALVE w/ 1/4" BRAKE LINES

| Run No. | | Fluid Pressure | | | Time | | Temperature | | | Flow Rate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $P_1$ | $P_2$ | $\Delta P$ | $t$ | | $T$ | | $Q$ | $Q$ |
| | | psi | psi | | sec. | | °F | | $in^3/sec$ | ml/sec |
| 11 | | 500 | 320? | | 62 | | 77 | Fluid at valve inlet + meter temp | | |
| 12 | | 500 | 320 | | 223 | | 78 | | | |
| 13 | | 500 | 320 | | 856 | | 77 | | | |
| 14 | | 500 | 320 | 180 | 30 | | 90 | | 1.020 | 16.7 |
| 15 | | 500 | 320 | 180 | 30 | | 89 | | 1.020 | 16.7 |
| 16 | | 500 | 320 | 180 | 30 | | 92 | | 1.020 | 16.7 |
| 17 | | 500 | 320 | 180 | 29 | | 94 | | 1.050 | 17.2 |
| 18 | | 500 | 320 | 180 | 29 | | 97 | | 1.050 | 17.2 |
| 19 | | 500 | 320 | 180 | 28 | | 99 | | 1.087 | 17.8 |
| 20 | | 500 | 320 | 180 | 28 | | 119 | | 1.087 | 17.8 |

REMARKS: * Union Carbide Chemical Co. - Ucon Brake Fluid PM-4016
$P_1$ & $P_2$ are the fluid pressures entering & leaving the valve
$t$ is the time required to fill a 500 ml flask
$T$ is the temperature in the 500 ml flask

FORM 64-1039

SHEET 3 OF 3

DATE 9/3/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 34-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Hydraulic Brake Fluid*
Through a .030/.032 Metering Value w/ 1/4" braking lines

| Run No. | | Fluid Press $P_1$ psi | $P_2$, psi | | Time $t$ sec | | Temp. $T$ °F | | $in^3/sec$ | Flow Rate $Q$ ml/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 | | 500 | 320 | 180 | 31 | | 92 | | .983 | 16.1 |
| 22 | | 500 | 320 | 180 | 31 | | 94 | | .983 | 16.1 |
| 23 | | 500 | 320 | 180 | 30 | | 96 | | 1.020 | 16.7 |
| 24 | | 500 | 320 | 180 | 31 | | 98 | | .983 | 16.1 |
| 25 | | 500 | 320 | 180 | 29 | | 100 | | 1.050 | 17.2 |
| 26 | | 500 | 320 | 180 | 29 | | 128 | | 1.050 | 17.2 |
| 27 | | 520 | 340 | 180 | 28 | | 132 | | 1.083 | 17.8 |
| 28 | | stopped test dirt in value | | | | | | | | |
| 29 | | | | | | | | | | |
| 30 | | | | | | | | | | |

REMARKS: * Union Carbide Chemical Co. - Ucon Brake Fluid PM-4016
t = time to fill 500 ml flask
T = fluid temp. in flask

FORM 64-1039

SHEET 1 OF 4

DATE 9/10/65

TIME 9/13/65

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO. _____

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO. _____

DESCRIPTION Flow Rate of Hydraulic Brake ~~Fluid~~ Fluid *
Through a .030/.032" Metering Value w/ 1/4" Brake lines

| Run No. | | Fluid Press. $P_1$ psi | $P_2$ psi | $\Delta P$ | Time $t$ sec | | Temp. $T$ °F | | $in^3/sec$ | Flow Rate $Q$ ml. per sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 480 | 300 | 180 | 50 | | 104° | | .610 | 10.0 |
| 2 | | 480 | 300 | 180 | 48 | | 107 | | .635 | 10.4 |
| 3 | | 480 | 300 | 180 | 51 | | 106 | | .598 | 9.8 |
| 4 | | 500 | 320 | 180 | 39 | | 122 | | .782 | 12.8 |
| 5 | | 500 | 320 | 180 | 40 | | 126 | | .764 | 12.5 |
| 6 | | 400 | 220 | 180 | 37 | | 125 | | .825 | 13.5 |
| 7 | | 400 | 220 | 180 | 34 | | 134 | | .898 | 14.7 |
| 8 | | 400 | 220 | 180 | 70 | | 87 | | .436 | 7.15 |
| 9 | | 400 | 200 | 200 | 45 | | 98 | | .678 | 11.1 |
| 10 | | 400 | 200 | 200 | 42 | | 104 | | .728 | 11.9 |

REMARKS: * SAE 50 Oil - Quaker State (Non-detergent)

FORM 64-1039

SHEET 2 OF 4

DATE 9/13/65
TIME 9/14/65

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO. _____
DEPT. 39-80
ENGINEER Paul Urban

TEST EQUIP. NO. _____

DESCRIPTION Flow Rate of Brake Fluid*
Through a .030/.032" Hydraulic Restriction Valve w/¼ tubing

| Run No. | | Fluid Pressure $P_1$ psi | Fluid Pressure $P_2$ psi | $\Delta P$ | Time $t$ sec | | Temp $T$ °F | | Flow Rate $Q$ ml/sec. |
|---|---|---|---|---|---|---|---|---|---|
| 11 | | 400 | 190 | 210 | 36 | | 114° | .537 | 13.7 |
| 12 | | 400 | 180 | 220 | 36 | | 114 | .537 | 13.7 |
| 13 | | 410 | ~~230~~ | 180 | 41 | | 117 | .476 | 12.2 |
| 14 | | 400 | ~~200~~ | 200 | 39 | | 109 | .497 | 12.7 |
| 15 | | 400 | 220 | 180 | 43 | | 111 | .499 | 11.6 |
| 16 | | 400 | 220 | 180 | 43 | | 113 | .499 | 11.6 |
| 17 | | 400 | 220 | 180 | 74 | | 86 | .412 | 6.75 |
| 18 | | 410 | 250 | 180 | 63 | | 41 | .477 | 7.81 |
| 19 | | 400 | 100 | 300 | 33 | | 100 | .422 | 15.1 |
| 20 | | 400 | 225 | 175 | 58 | | 94 | .526 | 5.62 |

REMARKS: *SAE 50 Oil - Quaker State (Non-detergent)

FORM 64-1039

DATE 9/14/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET



PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of ~~Hydraulic~~ Brake Fluid*

| | | Fluid Press. | | ΔP | Time | | Temp. | | | Flow Rate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | $in^3/sec$ | |
| 21 | | 400 | 225 | 175 | 44 | | 110 | | .696 | 11.4 |
| 22 | | 400 | 225 | 175 | 51 | | 103 | | .598 | 9.8 |
| 23 | | 400 | 225 | 175 | 44 | | 112 | | .696 | 11.4 |
| 24 | | 400 | 225 | 175 | 40 | | 114 | | .764 | 12.5 |
| 25 | | 400 | 225 | 175 | 36 | | 120 | | .849 | 13.9 |
| 26 | | 400 | 225 | 175 | 46 | | 112 | | .727 | 11.9 |
| 27 | | 400 | 225 | 175 | 40 | | 121 | | .764 | 12.5 |
| 28 | | 400 | 225 | 175 | 39 | | 120 | | .783 | 12.8 |
| 29 | | 400 | 225 | 175 | 39 | | 124 | | .783 | 12.8 |
| 30 | | 400 | 225 | 175 | 37 | | 127 | | .824 | 13.5 |

REMARKS: *SAE 50 Oil.

FORM 64-1039

SHEET 4 OF 4

DATE 9/14/65
TIME 9/15/65

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO
DEPT. 39-80
ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION FLOW RATE OF BRAKE FLUID *
THROUGH A .030/.032" METERING VALVE W/ 1/4 BRAKE LI

| | | FLUID PRESS. | | | TIME | | TEMP. | | | FLOW RATE |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ΔP | | | | | | |
| | | | | | | | | | in³/sec | |
| 31 | | 400 | 225 | 175 | 39 | | 122 | | .782 | 12.8 |
| 32 | | 400 | 225 | 175 | 36 | | 137 | | .848 | 13.9 |
| 33 | | 400 | 225 | 175 | 34 | | 140 | | .897 | 14.7 |
| 34 | | 400 | 225 | 175 | 37 | | 134 | | .824 | 13.5 |
| 35 | | 400 | 225 | 175 | 34 | | 139 | | .897 | 14.7 |
| 36 | | 400 | 225 | | 70 | | 87 | | .436 | 7.14 |
| 37 | | 400 | 225 | | ~~73~~ | 58 | 93 | | .526 | 8.62 |
| 38 | | 400 | 225 | | 55 | | 96 | | .555 | 4.04 |
| 39 | | 400 | 225 | | 53 | | 100 | | .576 | 9.43 |
| 40 | | 400 | 225 | | 49 | | 102 | | .623 | 10.2 |

REMARKS: * SAE 50 OIL

M 64-1039

SHEET 1 OF 1

DATE 9/15/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Brake Fluid * Through 1/4" Brake lines. W & W/O Valve, metering .030/.032

| Run No. | | Fluid Pressi $P_1$ psi | $P_2$ psi | | Time t secs | | Temp T °F | | $m^3$ [illegible] | Flow Rate Q ml/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 400 | — | | 12 | | 95 | | 5.09 | 83.3 |
| 2 | | 400 | 50 | | 52 | | 94 | | 1.17 | 19.2 |
| 3 | | 400 | — | | 7 | | 124 | | [illegible] | 143 |
| 4 | | 400 | 35 | | 44 | | 120 | | 1.37 | 22.7 |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |

REMARKS: Run # 1, 3 No valve 1000 ml per run in secs
Run # 2, 4 through valve

* SAE 50 Oil

FORM 68-1039

SHEET 1 OF 3

DATE 9/23/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION FLOW RATE OF BRAKE FLUID*
THROUGH A .030/.032" HYDRALIC METERING VALVE

| Run No. | Fluid Pressure $P_1$ psi | Fluid Pressure $P_2$ psi | Time $t$ sec | Temp. $T$ °F | | Flow Rate $Q$ in³/sec | Flow Rate $Q$ ml/sec. |
|---|---|---|---|---|---|---|---|
| 1 | 400 | 220 | 31 | 91 | | .98 | 16.1 |
| 2 | 400 | 220 | 31 | 91 | | .98 | 16.1 |
| 3 | 400 | 240 | 33 34 | 93 | | | 15.2 |
| 4 | 400 | 240 | 33 | 94 | | | 15.2 |
| 5 | 400 | 220 | 30 | 96 | | 1.02 | 16.7 |
| 6 | 400 | 220 | 30 | 98 | | 1.02 | 16.7 |
| 7 | 400 | 220 | 29 | 100 | | 1.05 | 17.2 |
| 8 | 400 | 220 | 29 | 102 | | 1.05 | 17.2 |
| 9 | 400 | 220 | 30 | 103 | | 1.02 | 16.7 |
| 10 | 400 | 220 | 31 | 104 | | .98 | 16.1 |

REMARKS: * Ucon Industrial Brake Fluid - Union Carbide Co.
t = time req'd to fill 500 ml flask



[DX 323, p 39]

FORM 64-1039

SHEET 2 OF 3

DATE 9/23/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO. #

DESCRIPTION Flow Rate of Brake Fluid *
Through a .030/.032" Metering Valve

| Run No | | Fluid Press. $P_1$ psi | $P_2$ psi | | Time $t$ sec. | | Temp $T$ °F | | | Flow Rate $Q$ ml/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | | 400 | 220 | | 29 | | 102 | | 1.06 | 17.3 |
| 12 | | 400 | 220 | | 30 | | 105 | | 1.02 | 16.7 |
| 13 | | 400 | 220 | | 30 | | 107 | | 1.02 | 16.7 |
| 14 | | 400 | 220 | | 29 | | 108 | | 1.06 | 17.3 |
| 15 | | 400 | 220 | | 29 | | 111 | | 1.06 | 17.3 |
| 16 | | 400 | 220 | | 30 | | 118 | | 1.02 | 16.7 |
| 17 | | 400 | 220 | | 29 | | 122 | | 1.06 | 17.3 |
| 18 | | 400 | 220 | | 29 | | 124 | | 1.06 | 17.3 |
| 19 | | 400 | 220 | | 29 | | 126 | | 1.06 | 17.3 |
| 20 | | 400 | 220 | | 28 | | 134 | | 1.09 | 17.9 |

REMARKS: * Ucon Industrail Brake Fluid - Union Carbide Co.
t = time reqd to fill 500 ml flask.

FORM 64-1039

SHEET 3 OF 3

DATE 9/23/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Brake Fluid *
Through a .030/.032" Metering Valve

| Run No. | Fluid Pressure $P_1$ psi | Fluid Pressure $P_2$ psi | Time $t$ sec. | Temp. $T$ °F | | Flow Rate $Q$ in³/sec | Flow Rate $Q$ ml./sec. |
|---|---|---|---|---|---|---|---|
| 21 | 400 | 220 | 29 | 120 | | 1.05 | 17.2 |
| 22 | 400 | 220 | 29 | 124 | | | 17.2 |
| 23 | 400 | 220 | 29 | 127 | | | 17.2 |
| 24 | 400 | 220 | 29 | 129 | | | 17.2 |
| 25 | 400 | 220 | 29 | 138 | | | 17.2 |
| 26 | 400 | 220 | 29 | 140 | | | 17.2 |
| 27 | 400 | 220 | 29 | 142 | | | 17.2 |
| 28 | 400 | 220 | 29 | 144 | | | 17.2 |
| 29 | 400 | 220 | 29 | 145 | | | 17.2 |
| 30 | 400 | 220 | 29 | 146 | | | 17.2 |

REMARKS: * Uconn Industrial Brake Fluid - Union Carbide Company
t - time reqd to fill 500 ml flask

FORM 64-1039

SHEET 1 OF 1

DATE 9/24/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Brake Fluid * w/ & w/o Metering Valves and through different size Metering Valves

| Run No. | Valve Size inches (orificedia.) | Fluid Pressure $P_1$ psi | Fluid Pressure $P_2$ psi | Time t sec | Temp. T °F | Flow Rate Q ml/sec | Flow Rate in³/sec |
|---|---|---|---|---|---|---|---|
| 1 | .030/032 | 400 | 0 | 20 | 91 | 25.0 | 1.58 |
| 2 | .025 | 400 | 0 | 36 | 94 | 13.9 | .85 |
| 3 | none | 400 | initial | 5 | 94 | 100. | 6.11 |
| 4 | .025 | 400 | 0 | 39 | 96 | 12.8 | .78 |
| 5 | .025 | 400 | 0 | 39 | 96 | 12.8 | .78 |
| 6 | .030/032 | 400 | 0 | 20 | 97 | 25.0 | 1.58 |
| 7 | .030/032 | 400 | 0 | 20 | 97 | 25.0 | 1.58 |
| 8 | none | 400 | initial | 5 | 98 | 100 | 6.11 |
| 9 | none | 400 | initial | 5 | 98 | 100. | 6.11 |

REMARKS: * Union Industrial Brake Fluid - Union Carbide Co.
1/4" hydraulic tubing used on test
t = time to fill 500 ml flask

$P_1$-$P_2$ dropped from 175 psi to 125 psi when temp went from 145°F to 90°F

FORM 64-1039

SHEET 1 OF 2

DATE 9/24/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Brake Fluid * through a .025" Metering Valve w/ ¼" connecting tubes.

| Run # | | Fluid Pressure $P_1$ psi | $P_2$ psi | | Time Sec $t$ | | Temp. $T$ °F | | Flow Rate $Q$ ml/sec | $in^3$/sec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 400 | 225 | | 46 | | 98 | | 10.9 | .665 |
| 2 | | 400 | 225 | | 47 | | 105 | | 10.6 | .65 |
| 3 | | 400 | 225 | | 47 | | 108 | | 10.6 | .65 |
| 4 | | 400 | 225 | | 46 | | 111 | | 10.9 | .665 |
| 5 | | 400 | 225 | | 45 | | 115 | | 11.1 | .68 |
| 6 | | 400 | 225 | | 46 | | 103 | | 10.9 | .665 |
| 7 | | 400 | 225 | | 46 | | 109 | | 10.9 | .665 |
| 8 | | 400 | 225 | | 46 | | 113 | | 10.9 | .665 |
| 9 | | 400 | 225 | | 45 | | 117 | | 11.1 | .68 |
| 10 | | 400 | 225 | | 46 | | 120 | | 10.9 | .665 |

REMARKS: * Ucon Industrial Brake Fluid - Union Carbide Company
t = time to fill 500 ml flask

FORM 64-1039

SHEET 2 OF 2

DATE 9/24/65

TIME

THE SINGER COMPANY
EXPERIMENTAL AND TEST
DATA SHEET

PART NO.

DEPT. 39-80

ENGINEER Paul Urban

TEST EQUIP. NO.

DESCRIPTION Flow Rate of Brake Fluid * through a .025" Metering Valve w/ ¼" Connecting Lines

| Run # | Fluid Pressure $P_1$ psi | Fluid Pressure $P_2$ psi | Time $t$ sec. | Temp. $T$ °F | Flow Rate $Q$ ml/sec | Flow Rate $Q$ in³/sec |
|---|---|---|---|---|---|---|
| 11 | 400 | 225 | 45 | 122 | 11.1 | .68 |
| 12 | 400 | 225 | 45 | 124 | 11.1 | .68 |
| 13 | 400 | 225 | 45 | 128 | 11.1 | .68 |
| 14 | 400 | 225 | 45 | 133 | 11.1 | .68 |
| 15 | 400 | 225 | 45 | 138 | 11.1 | .68 |
| 16 | 400 | 225 | 45 | 140 | 11.1 | .68 |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | | | | | | |
| | | did not change | ΔP setting | | | |
| 9/28/65 | 650 | 500 | 58 | 88 | 8.6 | .54 |

REMARKS: * Ucon Industrial Brake Fluid - Union Carbide Co.
t = time req'd. to fill 500 ml flask

DEFENDANT'S EXHIBIT 336

THE SINGER COMPANY

ELIZABETH PLANT • 321 FIRST STREET, ELIZABETH, NEW JERSEY • 201 FL 2-5200

March 15, 1966

RECEIVED
MAR 16 1966
BURTON C. PERSON

Mr. B. C. Person,
The Singer Company,
30 Rockefeller Plaza,
New York 20, New York.

Ford Motor Company Trip Report

RECEIVED
EXECUTIVE OFFICES
MAR 22 1966
Noted

Dear Sir:

The following are the highlights of the March 7th trip to Ford;

I. Tests conducted:

1. All wheels on painted soap strips

a) Standard vehicle - 1966 Ford Galaxie 500
b) Four wheels pumping
c) Rear wheels pumping

Unit would not release wheels. Cause determined to be restricter valve.

2. Two wheels on dry asphalt and two on painted soap strips

Conditions a, b and c as listed above. There was no appreciable improvement in stability when using the Perma device. The wheels on the soap strips did not release as quickly as the ones on the dry pavement. Cause was again determined to be the restricter valve.

3. Dry asphalt tests

Conditions a, b and c as listed above. A rough check on stopping distance for all three conditions at 40 M.P.H. revealed that they were equal. The runs taken with rear wheels pumping resulted in a less violent deceleration. The stability in all three cases was essentially the same.

D.P.E
336

4. Wet tests

Due to a malfunction of the recording instrument, this test will have to be re-run to obtain stopping distance data. The unit did function on all runs but showed no advantage in stability. The same three conditions were set up.

II. General Comments

All of the above tests were conducted with the vehicle transmission in neutral and the driver's hands off the wheel during braking. Although these conditions would not be prevalent in an actual panic stop, they minimize variables during testing and lead to more accurate comparisons. The tests were well organized and professionally conducted.

I requested that several runs under each condition be tried without the restricter valve. Mr. Sampson agreed to this and suggested that they try some valves with smaller pressure differentials as well. These tests will be completed in a week or two depending on weather conditions.

Yours very truly,

A. Romel,
Supervisory Engineer,
Central Engineering Staff,
Consumer Products Division.

AR/b

DEFENDANT'S EXHIBIT 380

DEF'S EX. 5

RECEIVED
DEC 29 (64)
GENERAL MANAGER'S
OFFICE

December 28, 1964

Mr. Robert Patton
The Singer Company
321 First Street
Elizabeth, New Jersey

Dear Bob:

Several weeks ago I discussed with you the urgent need to replace the few hundred units that are installed on consumers, stockholders and dealers cars. For the most part these cars are in New England and replacement could be made in our plant.

I would like to go on record that I consider it an emergency that these units be replaced with new production models and that a plan should be developed immediately to make the change before a serious accident occurs.

Very truly yours,

PERMA RESEARCH AND DEVELOPMENT COMPANY

Sam Karp,
Vice President, Marketing

SK:jb
cc: Robert Kloby

380



[DX 380, p 1]

After viewing all available copies of the preceding page, counsel for the Appellant believes that the preceding page reads as follows:

"December 28, 1964

Mr. Robert Patten
The Singer Company
321 First Street
Elizabeth, New Jersey

Dear Bob:

Several weeks ago I discussed with you the urgent need to replace the few hundred units that are installed on consumers, stockholders and dealers cars. For the most part these cars are in New England and replacement could be made in our plant.

I would like to go on record that I consider it an emergency that these units be replaced with new production models and that a plan should be developed immediately to make the change before a serious accident occurs.

Very truly yours,

PERMA RESEARCH AND DEVELOPMENT COMPANY

Sam Karp,
Vice President, Marketing

SK:jb
cc: Robert Kloby"

DEFENDANT'S EXHIBIT 409

1966-P2
DEF EX. 82

PERMA RESEARCH AND DEVELOPMENT COMPANY

I. Letter to Stockholder

II. Financial Statement-December 31, 1964

III. Brochure on Hydraulic Pressure Switch

IV. Brochure on Start-O-Matic

PERMA RESEARCH AND DEVELOPMENT COMPANY, NORTH ATTLEBORO, MASSACHUSETTS

DX 409

PERMA
RESEARCH AND DEVELOPMENT COMPANY

345 E. WASHINGTON, NORTH ATTLEBORO, MASSACHUSETTS 02761
AREA 617 TEL. 699-4600 • AREA 401 TEL. 725-6300

February 2, 1965

Dear Stockholder:

The purposes of this letter are (1) to advise you of the successful execution on December 21, 1964 of the agreement with The Singer Company which was unanimously approved by Perma's stockholders on December 10, 1964, (2) to describe again for you the nature and advantages of the Singer arrangement and to confirm your management's intentions with respect to the disposition of cash royalties to be received from Singer, (3) to bring to your attention the significant growth and earnings potential still available to your Company over and above the Singer arrangement from foreign markets, other products, etc., (4) to inform you as to your management's present thinking as to the future course of action which would best benefit the Company and its stockholders, and (5) to advise you of the proposals recently adopted or recommended by your Board of Directors to widen and enhance the public market for the Company's common stock, including a three for two stock split to be recommended for distribution in April, 1965.

The following details are lengthy but require your careful attention, since much of this information will be the basis for concrete proposals which will be covered in a subsequent letter, notice, and proxy statement to be mailed to you in advance of the stockholders meeting scheduled for late March, 1965.

## THE SINGER AGREEMENT

Under the final agreement signed on December 21, 1964 (which conformed substantially in all respects with the arrangement presented to and approved by Perma's stockholders on December 10, 1964), Perma is now placed in a much more favorable financial condition as to both its present assets and liabilities and its future profit position.

Perma has assigned and sold to Singer its United States and Canadian rights to the anti-skid unit in exchange for royalty payments based primarily on Singer's selling price to its marketing outlets summarized as follows:

(a) Perma received a net cash payment of $24,000 from Singer as at December 24, 1964, representing a total advance royalty payment of $64,000 for the Canadian rights, less a deduction of $40,000 applicable to fulfill Canadian distributor obligations for advance payment of product previously received in cash by Perma. The $64,000 represents advance royalties to be applied against the first 16,000 units sold by Singer.

(b) Perma received a further cash payment of $209,697 from Singer as at December 24, 1964 as advance royalties (in the form of a loan) all of which will be applied against the next 20,970 units sold by Singer, at the rate of $10.00 per unit. The $209,697 in cash received from Singer was applied in full to payment of liabilities of Perma.



[DX 409, p 2]

(c) After Singer has sold the first 36,970 units described in (a) and (b) above, Perma will receive additional cash royalties quarterly from Singer on the basis of (1) 10% of Singer's selling price to its outlets (presently about $5.00 royalty per unit) on units sold by Singer during the first five years and (2) 5%, similarly computed, on units sold during the next five-year period. (The foregoing rates apply only to sales to the "after" market. Singer will pay Perma on a 5% basis on all sales to new car manufacturers and/or 25% of royalties Singer obtains on any re-license by Singer to new car manufacturers.)

The royalty rates stated above are exceptionally high for the automotive field and give Perma a huge potential of cash flow. We are informed that Singer (1) has already manufactured over 30,000 anti-skid units of the first 50,000 scheduled as the initial production run, (2) has orders already on its books well in excess of the initial 50,000 unit production run, (3) has made a substantial investment in the anti-skid unit approaching two million dollars in connection with the obligation it assumed to take over the complete manufacturing, quality control and marketing of the unit for the United States and Canada, (4) has given the responsibility for the complete Perma program to Mr. Robert Kloby, one of Singer's capable executives (who has advised us he intends to see that the Perma anti-skid unit reaches its full sales potential; that since the product is to be marketed under the name "Perma Anti-Skid - By Singer," all steps are being taken to insure the highest quality to make it worthy of the Singer name), (5) has planned a full scale enthusiastic program to make the Perma unit a significant part of Singer's future business, and (6) has already commenced its newspaper and other promotions of the unit.

The foregoing factors give us confidence that substantial cash royalties will be generated in the near future from the Singer arrangement. In this connection, this will also serve to confirm to you that as the Company receives cash royalties from Singer, which will commence after the first 36,000 units have been sold by them, management will segregate such receipts and will not use such funds for any other purpose except for expenses in connection with stockholder meetings, the Singer contract, etc., until such time as Council furnishes advice, and until your vote as to the most desirable method of disposition of such cash in the best interests of the stockholders. Substantially all of our other current operating costs are being covered by the $9,800 being paid monthly to Perma by Singer under our separate Technical Services Contract with them, which runs for a minimum of six months.

To meet our responsibility to you to explore the question of the future course of action which would best benefit the stockholders, your management has reviewed its position with respect to Perma's assets other than the Singer agreement and, in the following paragraphs, there is set forth a summary of facts concerning other items which have significant growth and earnings potential to your Company.

## FOREIGN LICENSE POTENTIAL FOR ANTI-SKID UNIT

Perma has retained all other foreign rights to the Perma Anti-Skid. Initial market research has shown that there are numerous other countries in

which an agreement similar to the Singer agreement could be reached. The foreign potential, although overlooked to some extent by Perma because of United States activities, is actually larger than the United States market when combined. Over ten and a half million cars were produced last year compared with approximately eight million in the United States. (400,000 of the 10½ million foreign cars were sold in the United states.)

There is an 8[illegible]% automotive saturation in the United States as compared to only 28% saturation in Europe and other applicable foreign countries. There was an increase of 10% in automobile production in the United States in 1964 over the previous year 1963, as compared with a 22% increase in other countries.

In summary, our foreign potential may well realize a cash flow to Perma in excess of the millions we anticipate may be generated from the present Singer arrangement covering the United States and Canada.

## OTHER PRODUCTS

Because Perma has assigned to Singer the United States and Canadian rights to its most attractive product and because of the dramatic impact this product has presented, Perma's other products were all but forgotten. However, there are two other products which are potential profit makers if Perma were to promote them actively.

### Hydraulic Pressure Switch:

The hydraulic pressure switch designed by Perma has applications in the vast hydraulic pneumatics field for the control of electric circuit applications in the large machine industry in general, aircraft hydraulic controls, missile controls, pneumatic door openers, commercial air conditioners, etc.

These switches have been included in government specifications and are in use on jet test equipment for the Armed Services.

Sun Electric and smaller companies have been reordering these switches for over two years with good results. Perma has not promoted the sales of this switch because of the Anti-Skid activity, but the hydraulic switch field is large and could be pursued at a relatively low cost to Perma.

The advantages Perma has in this field are:

1. Unique design which allows miniaturization for limited space applications. Perma has patent protection on this design.
2. Low selling price due to low production cost as a result of design. Our selling price is ¼ of the selling price of the closest competitive switch with the same basic characteristics.
3. Explosion resistant housing which is desirable in applications where gas fumes are a problem.
4. High profit potential per unit to Perma.

Automatic Starter:

This product is another sleeper Perma has not yet pursued due to the Anti-Skid activity, although initial exposure some years ago resulted in the beginning of a mail order business.

This product automatically restarts the automobile engine in the event of stalling and eliminates stalling and starting frustrations due to roll back on hills, prevents the loss of power steering which is particularly hazardous on winding downgrades and restores power brakes which are lost due to engine failure. This whole package is simply installed on practically any automobile, American or foreign, in approximately 15 minutes and can be sold at retail for under $10.00, which provides a healthy profit margin.

## MANAGEMENT'S PRESENT THINKING AS TO PERMA'S FUTURE COURSE OF ACTION

Some stockholders have been under the impression that their future success and that of the Company rested substantially only in the Singer arrangement and that, on such basis, perhaps Perma should (1) stop all activities now other than to properly execute our six months Technical Services Contract with Singer, (2) eliminate all expenses other than those required by the Technical Services Contract, and (3) upon the expiration date of the Technical Services Contract or at a time meaningful to the best tax consequences, distribute the cash proceeds of the Singer contract to Perma's stockholders, or otherwise reduce Perma strictly to a royalty income entity for its stockholders.

In view of the huge potential available to Perma in addition to the Singer contract, your management feels the above course of action is not in the best interest of Perma's stockholders. The future course of action which would best benefit the Company and its stockholders (and which will be proposed at the upcoming stockholders meeting) is as follows:

(a) As previously affirmed herein, all royalties to be received by Perma in the future on the Singer contract shall be segregated by Perma and will not be used for any other purpose except for expenses in connection with stockholder meetings, the Singer contract, etc., until such time as council furnishes advice and until stockholders vote as to the most desirable method of disposition of such cash in the best interests of the stockholders,

(b) Provide required technical and related services to Singer at $9,800 per month, to facilitate product and marketing,

(c) Aggressively pursue and lay the ground work to capitalize on our foreign market opportunities for the anti-skid unit and, if merited, actively pursue the potential of the hydraulic switch, automatic starter and other products; however, to finance such action only from funds raised through the sale by Perma of authorized but unissued common stock or from such other sources or in such a manner as to not jeopardize the Singer royalties or the financial stability of the the Company,

(d) Take such steps as are deemed advisable to widen and enhance the public market for the Company's common stock, as hereinafter proposed.

Under the foregoing plan, Perma stockholders should realize not only the royalty potential of the Singer-Perma Agreement for the United States and Canada, but also income from advance and future anti-skid royalties in other countries, in addition to the potential profits that may be realized from actively pursuing the other products. These represent further growth possibilities for the company, which would in time be reflected in appreciation of value of the company's stock. Thus, all stockholders may realize the opportunity to take advantage of long term gains and an active market place in which their security can be traded.

## STOCK SPLITS AND OTHER PROPOSALS TO WIDEN AND ENHANCE THE PUBLIC MARKET FOR PERMA'S COMMON STOCK

Certain stockholders have shown concern that Perma may raise additional capital in the future by issuing its authorized but unissued common stock at the value of $5,000 per share which was applicable in sales made by the Company prior to the Singer agreement, and have expressed their feeling that such a valuation may no longer be realistic, based on the new position of the Company with the Singer agreement and the new profit avenues available to the Company. Stockholders have also expressed concern with respect to the limited nature of the public market for the Company's common stock.

Your management has recognized the foregoing situation and has, by recent action of its Board of Directors, approved the following measures:

(a) Proposed that the stockholders, at the upcoming meeting in March, approve an increase in the Company's authorized common stock from 825 to 1,300 shares (an increase of 475 shares), and that an additional one-half share for each share held by the stockholders, on a duly designated record date, be distributed to them in April, 1965, on the basis of a 3 for 2 stock split.

(b) Authorized immediate action to qualify the Company's shares under the "Blue Sky" laws of New York, Massachusetts, Connecticut and other states, where desirable and permissable, so as to widen the geographical areas in which brokers may properly trade in the Company's common stock.

(c) Authorized the President to bring up for discussion at the upcoming stockholders meeting a recommendation for a further split of the Company's stock on a 500 to 1 basis, if appropriate.

PERMA RESEARCH AND DEVELOPMENT COMPANY, NORTH ATTLEBORO, MASSACHUSETTS

(6)

After the approval of the increase in authorized stock to 1,300 shares and the distribution of approximately 410 shares to stockholders on the proposed 3 for 2 split, the Company would have approximately 65 shares of unissued stock. It is management's intention to make no further sales of unissued stock for less than $5,000 per share after the split (or the equivalent of $7,500 for each present outstanding share of stock).

FINANCIAL STATEMENT

The enclosed unaudited balance sheet of the Company as at December 31, 1964, gives effect to the Singer transactions as at December 21, 1964 described in detail in this letter, and to the elimination of our liability, in the sum of approximately $84,000, to Worcester Stamped Metal Company and American Emblem Company in the exchange of eight (8) shares of the Company's common stock, as approved at the last meeting of the stockholders.

Very truly yours,

PERMA RESEARCH AND DEVELOPMENT COMPANY

Frank A. Ferrini
President

F/P:jb
enc.

PERMA RESEARCH AND DEVELOPMENT COMPANY

Balance Sheet - December 31, 1964
(Prepared from books and records without audit)

ASSETS

| | | |
|---|---|---|
| Current assets: | | |
| Cash | | $ 38,427 |
| Accounts receivable | | 8,781 |
| Inventories, (Note 1) | | 66,764 |
| Prepaid expenses | | 2,100 |
| Total current assets | | $116,072 |
| Property, plant and equipment, at cost: (Note 2) | $136,651 | |
| Less - Accumulated depreciation | 35,289 | 101,362 |
| Patents and applications, at cost | | 5,268 |
| Other assets, at cost | | 1,277 |
| Deferred cost of royalty agreement (Note 3) | | 33,955 |
| Unrecovered promotional and development expenses, at cost (Note 4) | $336,847 | |
| Less - Accumulated amortization | 220,696 | 116,151 |
| | | $374,085 |

LIABILITIES AND CAPITAL

| | | |
|---|---|---|
| Current liabilities: | | |
| Notes payable due within one year (Note 5) | | $ 16,797 |
| Accounts payable | | 21,592 |
| Payroll deductions | | 4,387 |
| Accrued taxes, wages and interest | | 5,988 |
| Advance payment for service contract | | 6,535 |
| Total current liabilities | | $ 55,299 |
| Long-term notes payable (Note 5) | | 212,172 |
| Capital: | | |
| Common stock, authorized 825 shares of $1.00 par value, issued and outstanding 787.415 shares | $ 787 | |
| Paid-in capital | 844,281 | |
| | $845,068 | |
| Less - Treasury stock, at cost | 2,250 | |
| | $842,818 | |
| Accumulated deficit | (736,204) | 106,614 |
| | | $374,085 |

PERMA RESEARCH AND DEVELOPMENT COMPANY

NOTES TO FINANCIAL STATEMENTS - December 31, 1964
(Prepared from books and records without audit)

Note 1 - Inventories

Inventories have been valued at the lower of cost or market. Physical inventories were taken at December 31, 1964 and consisted of the following merchandise:

| | Skid | Brake | Total |
|---|---|---|---|
| Finished | $13,027 | $21,827 | $34,854 |
| Work in process | - | | |
| Raw material | 1,192 | 13,114 | 14,306 |
| | $14,219 | $34,941 | $49,160 |
| Promotional supplies | 17,604 | | 17,604 |
| | $31,823 | $34,941 | $66,764 |

Note 2 - Property, plant and equipment

On December 31, 1964, the property, plant and equipment consisted of the following:

| | |
|---|---|
| Land and building | $59,714 |
| Tooling | 44,365 |
| Machinery and equipment | 10,473 |
| Furniture and fixtures | 11,715 |
| Automobiles | 10,384 |
| | $136,651 |

Note 3 - Deferred cost of royalty agreement

This amount represents the net depreciated book value of tools and patents owned by the company which were transferred to The Singer Company in return for the royalty agreement signed on December 21, 1964. This amount will be amortized over the period of the royalty agreement.

Note 4 - Unrecovered promotional and development expenses

During the period from the inception of the company in 1959 through June 30, 1963, the company had not been able to start normal selling and marketing operations on a continuous basis due, primarily, to problems relating to production tooling and acquisition of its products; therefore, management believed that a portion of these expenditures, which are in the nature of starting-up costs, should be deferred and charged to future operations once the products were ready to be marketed. These expenses are being amortized over a sixty-month period.

PERMA RESEARCH AND DEVELOPMENT COMPANY

NOTES TO FINANCIAL STATEMENTS - December 31, 1964
(Prepared from books and records without audit)

Note 5 - Notes payable

Notes payable consisted of the following:

| | Due within one year | Due after one year |
|---|---|---|
| Secured: | | |
| First mortgage on real estate | $15,000 | |
| Chattel notes on automobiles | 1,797 | $ 2,475 |
| Unsecured: | | |
| The Singer Company, due December 20, 1969 | - | 209,697 |
| Total due within one year | $16,797 | |
| Total long-term debt | | $212,172 |

Land and building amounting to $59,714 is subject to a first mortgage on real estate of $15,000, due March 18, 1965. Motor vehicles costing $6,818 are subject to chattel mortgages amounting to $4,272, which are due to be paid by May, 1967.

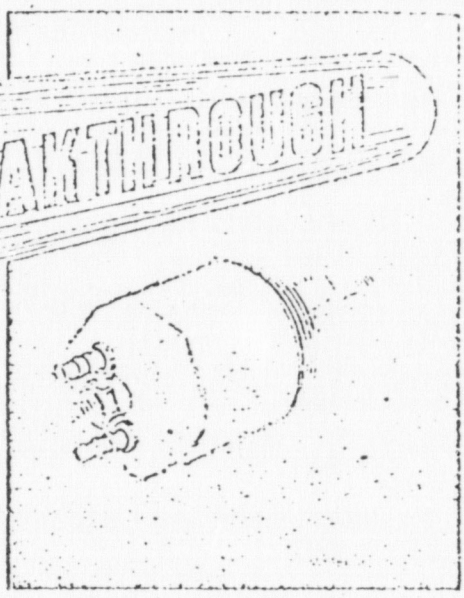
On December 21, 1964, the company entered into an agreement with The Singer Company transferring all of it's right, title and interest in the patents for the Anti-Skid Control Device in the United States and Canadian areas, including certain tooling it had acquired for the manufacture of this product. In consideration for this agreement, The Singer Company paid the company $24,000, and assumed an obligation of a distributor for $40,000. It also paid debts and assumed certain liabilities of the company totalling $209,697.13 for which it received a note due on December 20, 1969. The agreement also included provisions for the payment of royalties by The Singer Company for a period of ten years. No royalties are payable on the first 16,000 units sold, and the royalties payable on the next 20,970 units will be applied toward the full payment of the note payable of $209,697.13.

# A PRICE BREAKTHROUGH

in HYDRAULIC CONTROLS

NEW Compact Design

# PRESSURE SWITCH



Provides answers to problems where size and weight are major factors in power plants, rockets, missiles and industrial application.

**O ADJ ABLE RANGE**

Capable of withstanding pressure far in excess of its operating range, it can be set in seconds to operate at any required range from 0-3000 P.S.I.

**O HERMETICALLY SEALED**

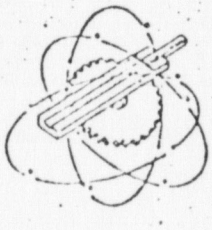
This switch can be used in applications where explosive fumes are present.

**O SILVER CONTACTS**

For high electrical loads—will minimize arcing.

**O ACCURACY**

To a degree found only in switches many times its cost make it particularly desirable for use on hydraulic starters for diesel engines, aircraft hydraulic systems, or any hydraulic system where the circuit must be closed at a predetermined pressure.



*For further details write to*

PERMA

RESEARCH AND DEVELOPMENT COMPANY

345 E. WASHINGTON, NO. ATTLEBORO, MASSACHUSETTS

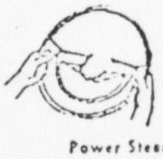
# END STALLING FRUSTRATION!

## AUTOMATICALLY

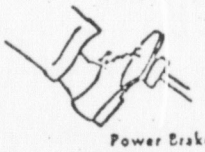
## START-O-MATIC

## AUTOMATICALLY

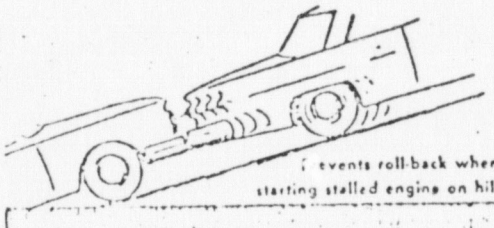
PREVENTS LOSS OF:



Power Steering



Power Brakes



Prevents roll-back when starting stalled engine on hill

The START-O-MATIC is a "hidden robot" that AUTOMATICALLY starts a motor whenever it stalls . . . without the driver having to do a thing.

This means safety, convenience, and complete automation. It gives positive protection against loss of power steering or power brakes because of a stalled engine. Even if the engine stalls because of mechanical failure or out of gas, the START-O-MATIC will turn the engine over sufficiently to operate power steering and power brakes. Remember how hard it used to be to try to steer or stop a car equipped with power steering and power brakes when the engine stalled? This can't happen with the START-O-MATIC on your car.

It puts an end to the aggravating roll-back on hills or in traffic as you try to re-start an engine that died . . . the START-O-MATIC does it for you . . . No more embarassing situations of stalling in traffic, horns blowing at you, car rolling into and bumping the car ahead or behind you.

Perma's handy START-O-MATIC kit can easily be installed in a matter of minutes.

**PERMA**
RESEARCH AND DEVELOPMENT CORPORATION
345 E. WASHINGTON ST., NO. ATTLEBORO, MASSACHUSETTS

DEFENDANT'S EXHIBIT 417

SINGER
[illegible] FIRST STREET • ELIZABETH, N. J.

MEMORANDUM

TO: Mr. C.W. Brocker, Assistant General Manager

FROM: Robert A. Kloby, Manufacturing Manager
Perma Operations

DATE: February 16, 1965

REFER TO: RAK:HL

SUBJECT: Perma Anti-Skid Program

On January 7, 1965, Mr. P. Phelps wrote to Mr. S.J. Murphy concerning certain points of emphasis which had been discussed from time to time during the negotiations with Perma and Monitor.

It would appear that items 1 through 4 in the aforementioned letter, copy attached, can best be answered by you. I shall, therefore, answer items 5 through 13 based on events to date.

5. Close liaison is being maintained with Monitor in the following manner:

   a. Daily telephone contact.

   b. Four field trips to date with Monitor personnel.

   c. Regular biweekly meetings with Monitor at Elizabeth to discuss progress and problems of mutual concern.

5a. Monitor's requirements and weekly schedule is being met with two exceptions:

   a. Two variable kit numbers requiring a special four inch flexible shaft extension, which is on order and will be available in about six weeks. These are not high priority items and do not hamper the Monitor Marketing Program.

   b. We are behind in dual Perma-Vac units due to a technical problem encountered in the unit or the test stand. Thirty-six duals have been shipped to Monitor to date, with another shipment expected this week. We are vigorously pursuing this problem, however, Monitor does have dual units on hand and the situation has not as yet become critical.

D.P.E. 417

EXH. NO. 371
POHAK, REPORTER
11/18/70

5b. We have seen evidence that Monitor is preparing advertising and promotional copy and a script for a TV film. They have been working with Audio Reproductions, Incorporated, on the latter and this firm was recommended to Monitor by Mr. Hough.

5c. As previously mentioned, we have kept very close to Monitor in order to observe their marketing technique and progress. Mr. J. Remias has been given the responsibility for variable kits, adaptors and installations. He has made several unassisted installations and is becoming quite knowledgeable in the techniques and problems involved in this area.

6. By virtue of Monitor's contract with Singer, Monitor is required, as soon as possible, to submit weekly orders four weeks in advance of shipment. This will give us some time to anticipate requirements and have the proper inventory of finished goods on hand. In addition, we are establishing minimum inventory quantities on '64 and '65 model variable kits. These quantities will be adjusted as we build sales history.

7. Concerning prototyping, we prototype 1965 vehicles upon request from Monitor since they are in the best position to know which kits they can sell. Prototyping of 1966 and subsequent models will be handled by virtue of section 10, page 8, of our agreement with Monitor, which reads as follows:

> "Models. By August 1 of each year during the term of this Agreement, Monitor shall give written notice to Singer, listing each make and model automobile for the subsequent model year which it wishes to be prototyped, in order of importance to Monitor. Singer shall, within six (6) weeks of public introduction of each such make and model, notify Monitor of its progress in prototyping such make and model and will generally consult from time to time with Monitor with respect to availability of a Product for various new makes and models. Singer shall provide a list, which it shall keep current, of all vehicles by make and model (including model year) for which a Product is available, and Monitor's minimum purchase requirements hereunder must be made from such list."

8, 10, 13. These items have been covered by Mr. Rowel's report to me, a copy of which is attached.

9. The Singer name is not being used on the product or the product packaging, except for the warranty card, which is required by law. Any intention to use the Singer name, either on the product or in advertising and promotional material, will first be cleared with the appropriate New York departments.

11. We keep in contact with our legal counsel on all matters which may come within the jurisdiction of the Sherman Anti-Trust Act.

12. A procedure has been established in the contract and outside of the contract for approving promotional material. Mr. Phelps has been acting in our behalf in clearing such material through New York Executive Office.

I trust this report adequately covers the items in question.

RAKloby

Robert A. Kloby

Encl.

CC: Mr. J. Fecko

February 11, 1965

Item 8:

Experimental test data is recorded on "data sheets" during the tests. Perma has been notified, in writing, to document test data and has been provided data sheets for this purpose. Endurance tests are being conducted on "Gear Boxes" and "Sensing Units" with results being documented in the form of data sheets and reports.

Item 10:

The following engineering services have been obtained from Perma during the month of January.

a. Test specifications for Dual Perma-vac Unit. A copy of the stopping distance tests made at the Cadillac Motor Company. Test report of locking pressures required at various speeds on dry pavement for a 1962 Cadillac.

b. A Dual Perma-vac Unit was field tested and turned over to Singer for use as a test reference master.

c. A schematic diagram of the dual hydraulic system.

d. Test data of stopping distance on a 1964 Plymouth V8 with power brakes and a 1964 Chevrolet V8 without power brakes conducted at Perma.

e. A copy of stopping distance tests performed by the New Hampshire Motor Vehicle Research on a 1962 Chevrolet V8 without power brakes.

f. A single piston Perma-vac Unit was field tested and turned over to Singer for use as a reference master.

g. A test was conducted on six different types of vehicles to determine the locking pressures required at different speeds on dry pavement. A report of these tests were turned over to Singer.

h. A design change recommendation regarding the Perma-vac spring was submitted. This change may increase the yield pressure after vacuum.

i. Response time of sensing unit. Oscillograph tapes of unit recorded during operation on a 1964 Ford V8.

j. Establishment of torque requirements (static loads) for torque transmitting components.

k. File data on endurance tests, problems encountered on earlier models and 1964 field reports.

l. Weekly reports on environmental testing of latest gear box design.

m. Summary of limitations of Anti-Skid Control System.

n. Endurance test data of earlier model Anti-Skid Units.

o. Evaluation of new method of mounting adaptors in Ford, Chrysler and American Motor vehicles.

p. A reference manual used on earlier model skid devices which includes technical data for dealer trouble shooting.

q. Prototyping data (instruction sheets and parts lists) for 1964-65 Rambler Classic; 1964-65 Rambler American; 1/2 - 3/4 - 1 Ton Ford Truck V8 and 6 cylinder 1962-63-64.

r. Consultation regarding urgent field problems was given in the form of telephone conversations. Discussions of unit function and development problems were discussed in great detail during a visit by Singer personnel to Perma.

s. Thirty-six special Ford adaptors were made by Perma and shipped to Singer at no charge. The following varieties were received:

29 - 3FAS-16
1 - 3FAS-15
4 - 3FAS-17
2 - 3FAS-19

Item 13:

Data is being collected and evaluated for use in preparing a performance specification for the product.

DEFENDANT'S EXHIBIT 479

June 25, 1965

Organization Announcement

As a further step in the Company's organizational program, it has been decided to establish a new operating Division which will bring together under single divisional management most of the U S. units primarily concerned with consumer products. The new Division will be known as the Consumer Products Division. It will be comprised of the following existing units:

- Consumer Products Division (including KLH)
- Family Products Division, Elizabeth, N.J (presently part of the Manufacturing Division)
- Wood Products Division, Trumann, Arkansas (presently part of the Manufacturing Division)
- Motor Products Division, Anderson, S.C. (presently part of the Special Products Division)
- A Product Development group formed from part of the Elizabeth Laboratory of the Research and Development Division

The above changes will become effective June 28, 1965, the first day of the Company's third quarter. On that date the new Division will assume operating responsibilities for all of the listed units.

Mr. Alfred di Scipio has been appointed head of the new Division Appointments to the staff of the new

Division will be announced from time to time by Mr. di Scipio.

The CPD Product Development Group formed at Elizabeth will be responsible for relatively short-term development and engineering of new products intended for marketing in the U S by the new Division. The balance of the present Elizabeth Laboratory will be constituted as a separate Product Development Group which will continue as a part of the R&D Division and will continue to perform relatively short-term development and engineering of new products intended for foreign markets. In common programs involving the development of products intended to be marketed both by the new Consumer Products Division and by some or all of the other operating Divisions of the Company, the Product Development Group with primary interest in the project will take the lead in completing it and the other Group will participate to the extent necessary to provide products specifically designed to meet the needs of the markets which it serves. Denville Laboratory will continue under the administration of the R&D Division and will continue to perform relatively long-term research and development aimed at both the U.S. and foreign markets.

All this constitutes a further major step in implementing the organizational program started some years ago to bring together under single divisional control, to

the extent feasible, line responsibility for the principal operations and functions relating to major segments of the Company's business in designated geographical and product fields. The present step has been carefully planned and is expected to produce substantial increases in operating efficiency in the United States consumer products field and improved sales and earnings. I am sure that all persons affected directly or indirectly by these changes will cooperate fully to enable us to realize these objectives.

Donald P. Kircher

DEFENDANT'S EXHIBIT 487

SINGER
30 ROCKEFELLER PLAZA • NEW YORK N Y 10020

MEMORANDUM

TO: Mr. A. di Scipio

FROM: B. C. Person

DATE: July 26, 1965

REFER TO:

SUBJECT: PROPOSED STUDY - PERMA ANTI-SKID CONTROL

Attached is a memorandum presenting the study plan for the Perma Anti-Skid Control. This memorandum has been prepared for the use of the Study Team to identify the specific questions to be answered and for use in discussions with individuals not familiar with the device and this study.

The action plan showing responsibility assignments and target dates will be forwarded shortly.

Director of Technical Services
BCP:lk
Att.

cc: Messrs. S. Boriss
R. H. Elman
J. E. McConnaughy
D. McKearnan
B. J. Murphy

DX-487
4/15/74

RECEIVED
JUL 26 1965
Alfred di Scipio

DX #487



[DX 487, p 1]

July 23, 1965

PERMA ANTI-SKID CONTROL

PROPOSED STUDY

This memorandum outlines the steps to be taken in a comprehensive study of the Perma Anti-Skid Control. The purpose of the study is to make an objective evaluation of this product in terms of its technical validity and potential contribution to The Singer Company's product line. This will provide CPD management with a firm base on which to decide its course of action.

Background of the Study

Responsibility for the Perma Anti-Skid Control project was transferred from the Manufacturing Division to the new Consumer Products Division on June 28, 1965, since the development work had been done at the Elizabeth Plant, which became part of the new division. A few months after the Manufacturing Division acquired the rights to this product, they discovered several technical deficiencies which caused them to stop shipment and sale of the units. The technical deficiencies with the product reportedly have been solved and the device is now said to be ready for full-scale marketing consideration.

Importance of the Study

A thorough study of this project is important because:

1. The Perma Anti-Skid Control represents a major product line decision. It is a safety device that becomes part of the basic operation of a vehicle.

2. The existing and potential exposure of Singer to legal action may be extensive. They involve:

   (a) Existing commitments to a distributor - Monitor Enterprises, Inc. - to supply units for sale

   (b) Approximately 180 units of inadequate design already installed on vehicles

   (c) The possibility of accidents with cars equipped with this device which may reflect unfavorably on the Singer name and increase our insurance rates.

3. The Company already has made a substantial investment in it - $1\frac{1}{2}$ to $2 million.

4. Profits from the product may be substantial. The existing pro forma profit and loss statements show substantial earnings.

.....continued

Nature and Scope of the Study

The importance of this decision requires authoritative answers to specific questions in six key areas which influence the course of action: (1) technical validity of the product; (2) implications of the use of the Singer name; (3) legal implications of exposure; (4) financial evaluation; (5) marketing evaluation; and (6) divesture alternatives. To carry out this study, a special six-man task force of appropriate Company personnel will provide qualified coverage on each major study area. In addition, other qualified experts within and without The Singer Company will be consulted as needed.

Specific Questions to be Answered

The following material outlines the specific questions to be answered by the study:

1. Technical Evaluation. This evaluation will cover both the single and double units. Evaluations will be obtained from four qualified groups: (a) Elizabeth Plant; (b) Research & Development Division; (c) competent outside technical consultant, such as Cornell University Laboratories; and (d) the four major automobile companies.

   - Is the device now fully developed and ready for production and a major marketing effort?
   - If not fully developed, what are the specific deficiencies? What is the time and cost requirement to complete development?
   - What are the standard manufacturing costs at reasonable levels of production?

2. Use of the Singer Name.

   - What are the implications of using the Singer name on this product?
   - What alternative approaches might be used and what are their advantages and disadvantages?

3. Legal Review.

   - What exposure exists from units now on automobiles?
   - What is the exposure related to our contract with Monitor Enterprises, Inc.?
   - What is the nature of exposure in the future if these products are marketed?
   - What is the nature of the patents we purchased and what is their business value?

.....continued

Nature and Scope of the Study

Specific Questions to be Answered

3. Legal Review. (continued)

- What is Singer's position in regard to licensing other manufacturers?
- Do we have redress against Perma for the deficiencies in design?

4. Complete Financial Review.

- What is the value and condition of existing inventory on
  (a) existing units on cars?
  (b) units in the field but not on cars?
  (c) inventory at the Elizabeth Plant?
- What are the financial implications of possible damage actions?
- What will the cost be if the project is terminated?
  (a) write-off of inventory
  (b) cost to recall units
- What are the pro forma profit and loss statements based on the findings of this study?

The CPD Controller's group will work in conjunction with the Corporate Controller's Department.

5. Marketing Evaluation.

- What is the potential market by class of customer?
- What are the economics for various means of distribution and what cost level must be maintained to keep this a profitable item?
- How much promotional expense can be expected under present marketing plans?

6. Alternatives for Divesture.

- What alternatives for divesture are available if (a) the product is technically successful but Singer does not wish to enter this product line, and (b) if additional development work is necessary?

.....continued

Task Force Members

The members of the Perma Anti-Skid Control Task Force will be:

S. Boriss - Manager of Special Services

R. H. Elman - Administrative Assistant to the Vice President

J. E. McConnaughy, Jr. - Controller

D. McKearnan - Development Specialist - Division of Corporate Development

S. J. Murphy - Assistant Vice President and General Manager of the Elizabeth Factory

B. C. Person - Director of Technical Services

The Chairman of the Task Force will be Mr. Person and the Secretary, Mr. Elman.

Timetable

The timetable for this study and its completion date will most likely hinge upon the arrangements that can be made with the automobile companies to evaluate the device. When this is known, a firm timetable will be prepared and presented.

BCPerson

Director of Technical Services
BCP:lk

DEFENDANT'S EXHIBIT 502

CORNELL AERONAUTICAL LABORATORY, INC.
OF CORNELL UNIVERSITY
P. O. BOX 235 • BUFFALO, NEW YORK • 14221
TELEPHONE 716-632-7500

1 September 1965

RECEIVED
SEP 3 1965
BURTON C. PERSON

Mr. Burton C. Person
Director of Technical Services
The Singer Company
30 Rockefeller Plaza
New York, New York 10020

Dear Mr. Person:

In response to your recent visits to the Laboratory, the Transportation Research Department suggests a three-phase program of research relative to the Perma Anti-Skid Control System.

1. Engineering Evaluation

A. The Perma Anti-Skid System

In this initial phase of the program, the specific device Singer owns will be reviewed from a technical viewpoint concerning its (a) advantages, (b) disadvantages, and (c) modes of failure. No experiments will be performed and this evaluation will be a matter of engineering opinion.

B. Review of ACIR Data

A brief survey of ACIR (Automotive Crash Injury Research) accident cases will be performed to produce a gross estimate of the total percentage of injury-producing accidents in which the loss of steering control, through skidding produced by brake application, was a probable factor in causation (e.g., single-vehicle accidents in which skid marks lead straight to a roadside obstacle). Note that the findings from ACIR data must be nonproprietary, because of existing ACIR policy regarding the use of data gathered under support of public funds.

4/15/74

#502

CORNELL AERONAUTICAL LABORATORY, INC. 1 September 1965

To: Mr. Burton C. Person
The Singer Company
New York, New York

2. Test Program

The performance of the Singer system will be compared with that of (1) other available brake pulsing systems, (2) a standard braking system with "rain" tires, and (3) a "standard" automobile. Stopping distance from speeds of 30, 50 and 70 mph will be compared on wet and dry pavements. Obstacle avoidance through steering control while braking will also be compared.

3. Analytical Study

A computer simulation will be developed to perform an investigation of fundamental relationships in pulsing and anti-skid braking systems. Through parameter variations, optimum system characteristics will be investigated. Experiments will be performed to validate the computer simulation.

It is estimated that parts A and B of the first phase will cost approximately $3000 and $5000 respectively. The technical details and costs of the second and third phases are as yet indeterminate, since the extent of these phases depends on the results of the initial phase.

Please let me know if the above program as outlined meets your objectives and if you wish us to submit a firm proposal on any of the tasks.

Very truly yours,

Robert A. Wolf
Head, Transportation Research Dept.

RAW/ers

DEFENDANT'S EXHIBIT 529 [DX 529, p 1]

THE SINGER COMPANY ELIZABETH, NEW JERSEY

RECEIVED
PATENT DEP
NOV 17 1965
Ans'd

November 16, 1965

Mr. D.C. Person, Director of Technical Services
The Singer Company
Consumer Products Division
30 Rockefeller Plaza
New York 20, New York

Evaluation of Perma "Fail Safe" Modification

Dear Mr. Person:

Please find attached our engineering evaluation and conclusions regarding the latest modifications to the Perma Anti-Skid Control which were submitted by Mr. F. Perrino in an effort to supply a "Fail Safe" feature for this unit.

Yours very truly,

Robert A. Kloby
Manufacturing Manager
Anti-Skid Control
Consumer Products Division

RAK:hl

Encl.

PLF
FOR IDENTIFICATION
4/1/74

D.P.E. 529

DX-529 ijk 4/17/74

E-I180

SINGER

# MEMORANDUM

TO: Mr. R. A. Kloby - Manufacturing Manager - Anti-Skid Control

FROM: A. Romel

DATE: November 12, 1965 REFER TO: AR:ms

SUBJECT: Fail-safe Evaluation of Design Modifications

We have completed our engineering analysis of the fail-safe aspects of the design changes submitted by Perma. The modifications do improve a majority of the undesirable conditions that were inherent in the old design; however, the system does not fail-safe under all conditions. As indicated in the analysis summary, these conditions can be grouped into two categories. The first group lists three conditions under which the unit would not fail-safe leaving the driver in a helpless position. The second group lists conditions under which the driver would be able to obtain additional brake pressure by releasing and reapplying pedal pressure.

Attached is the summary and details of the analysis that was made.

A. Romel

A. Romel, Manager
Manufacturing Engineering

Att.

November 10, 1965

## SUMMARY OF FAIL-SAFE ANALYSIS

Conditions under which new design will not fail-safe.

(Fail-safe is understood to mean that the system would return the ability of obtaining at least the same output pressure that could be obtained with the original brake system).

1. Under the following conditions the unit will not fail-safe regardless of what is done by the driver.
   a. Vacuum to front of Perma-Vac is cut off during a cycle by a kinked hose or stuck transfer valve with atmospheric port open and rotary valve jammed or sluggish.
   b. Failure of Perma-Vac spring.
   c. Piston "O" ring seals leaking.
2. Under the following conditions the unit would not fail-safe unless the driver released and reapplied pedal pressure when more than 500 p.s.i. was required to stop the vehicle.
   a. Rotary valve jammed in open position.
   b. Pressure switch fails to open.
   c. Governor drive cable rotates erratically.
   d. Cam gear hangs up.
   e. Complete vacuum failure (stalled engine).
   f. Low source vacuum.
   g. Vacuum delivery cut off to transfer valve during cycling.
   h. Transfer valve sticks in either position during cycling.
   i. Micro switch jammed in closed position.

November 10, 1965

# FAIL-SAFE ANALYSIS OF MODIFIED TRANSFER VALVE

| Failures that Eliminate or Detract from Fail-safe Features | Probability of Failure Occurring and General Comments |
|---|---|
| 1. Valve stuck with atmospheric port open. | 1. Experiences encountered during previous tests on valves of this type strongly indicate that it is prone to such a malfunction.<br><br>Reasons:<br><br>a. Fit between bore and piston must be reasonably close to prevent excessive leakage of fluid. This condition of binding due to size changes attributed to temperature variations and differences of expansion coefficients of components.<br><br>b. Deposits of carbon and lead from manifold gases on piston and bore could cause binding.<br><br>c. Foreign matter entering diaphragm chamber thru bleed hole or vacuum hole port could cause binding of diaphragm. |
| 2. Sluggish valve due to binding, dirt, etc. increases the response time of the unit. With continuous vacuum applied to rear chamber, the vehicle would be without brake power for a considerable length of time. | 2. Over a period of time, this condition is likely to occur due to the above reasons. |

D

| Failures that Eliminate or Detract from Fail-safe Features | * Probability of Failure Occurring and General Comments |
|---|---|
| 3. Plugging of bleed hole by contaminants would cause valve to stay in open atmospheric port position once it was actuated. (See item 1) | 3. Since the unit is only expected to be actuated occasionally, it would seem probable that plugging might occur over a period of time. If the unit were actuated frequently enough, the foreign matter would probably be blown out or sucked into the diaphragm chamber. |
| 4. Valve stuck with vacuum port open. | 4. Same as item 1. |
| 5. Poppet valve fails to seat under low vacuum condition. | 5. Proper selection of bore sizes, etc. would rule out this possibility. |
| 6. Poppet valve spring fails. | 6. Unlikely. |
| 7. Rubber poppet may crack, wear, or deform causing malfunction of fail-safe feature. | 7. Life testing would determine when it should be replaced. |

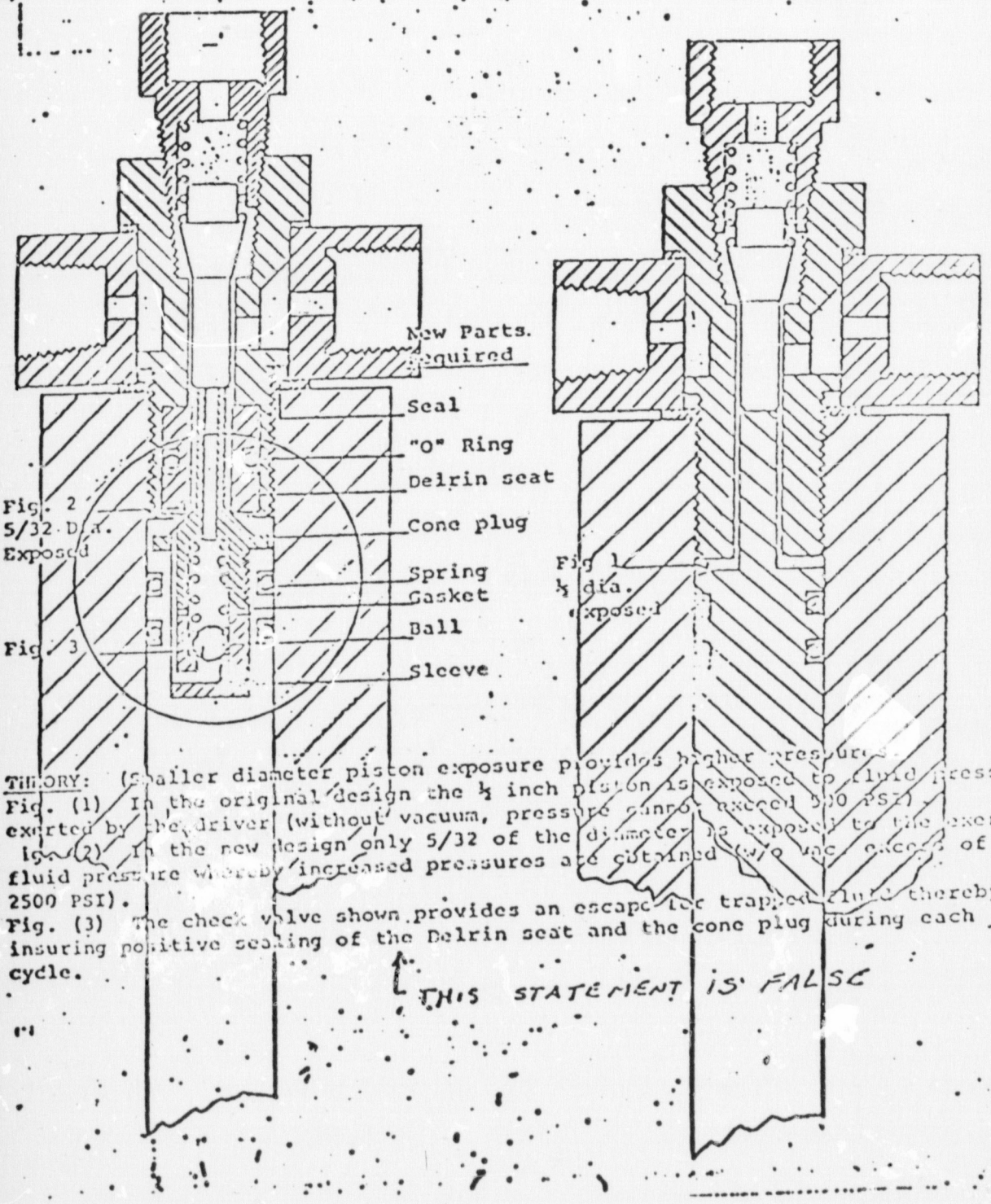
* An opinion stated without the benefit of test data

MODIFICATION FOR HIGHER PRESSURES

Schematic #2

NEW DESIGN
W/O Vac. 2500 PSI
W/ Vac. 6000 PSI

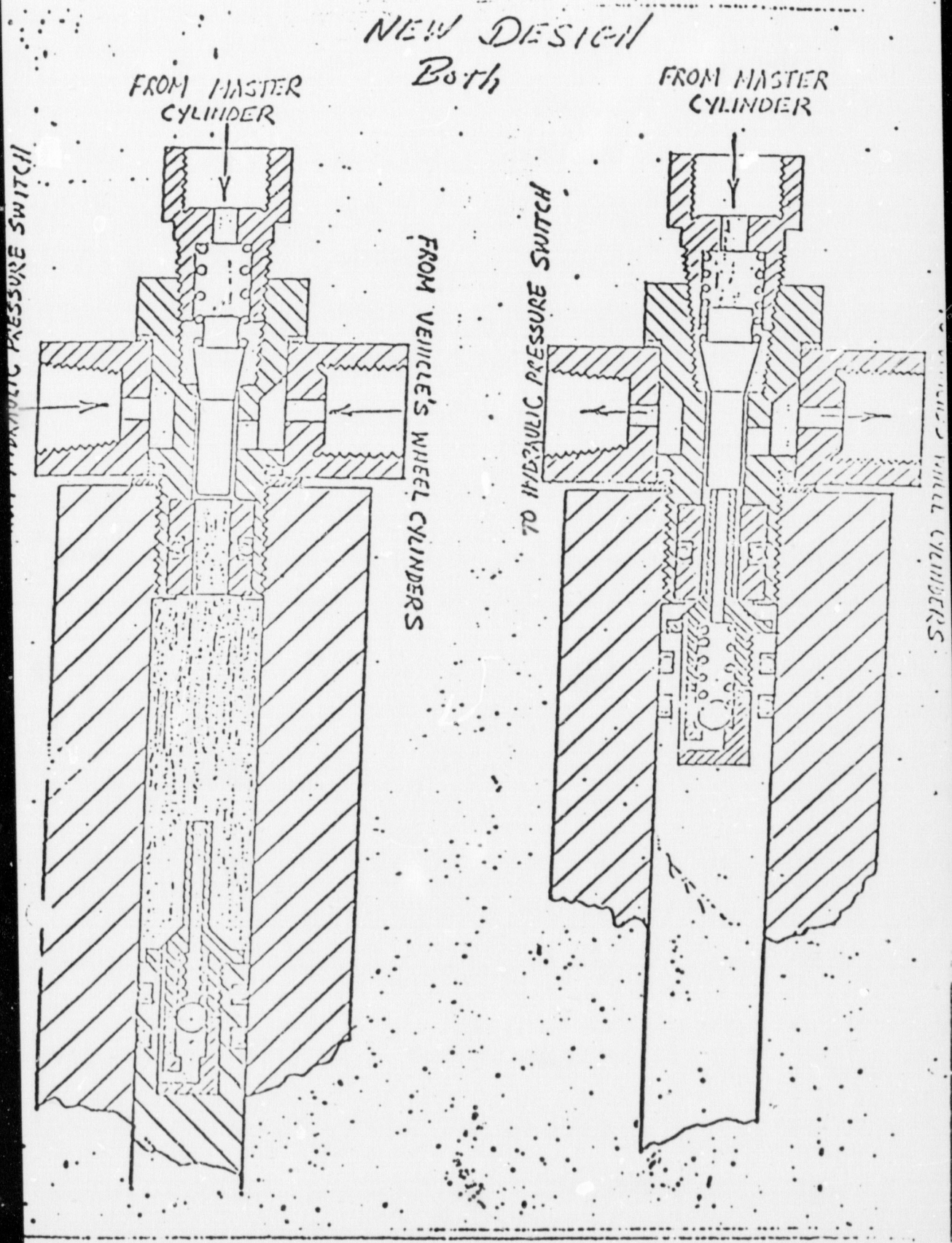
ORIGINAL DESIGN
W/O Vac. 500 PSI
W/ Vac. 1200 PSI




THEORY: (Smaller diameter piston exposure provides higher pressure) Fig. (1) In the original design the ½ inch piston is exposed to fluid pressure exerted by the driver (without vacuum, pressure cannot exceed 500 PSI) is (2) In the new design only 5/32 of the diameter is exposed to the exerted fluid pressure whereby increased pressures are obtained (w/o vac. excess of 2500 PSI).

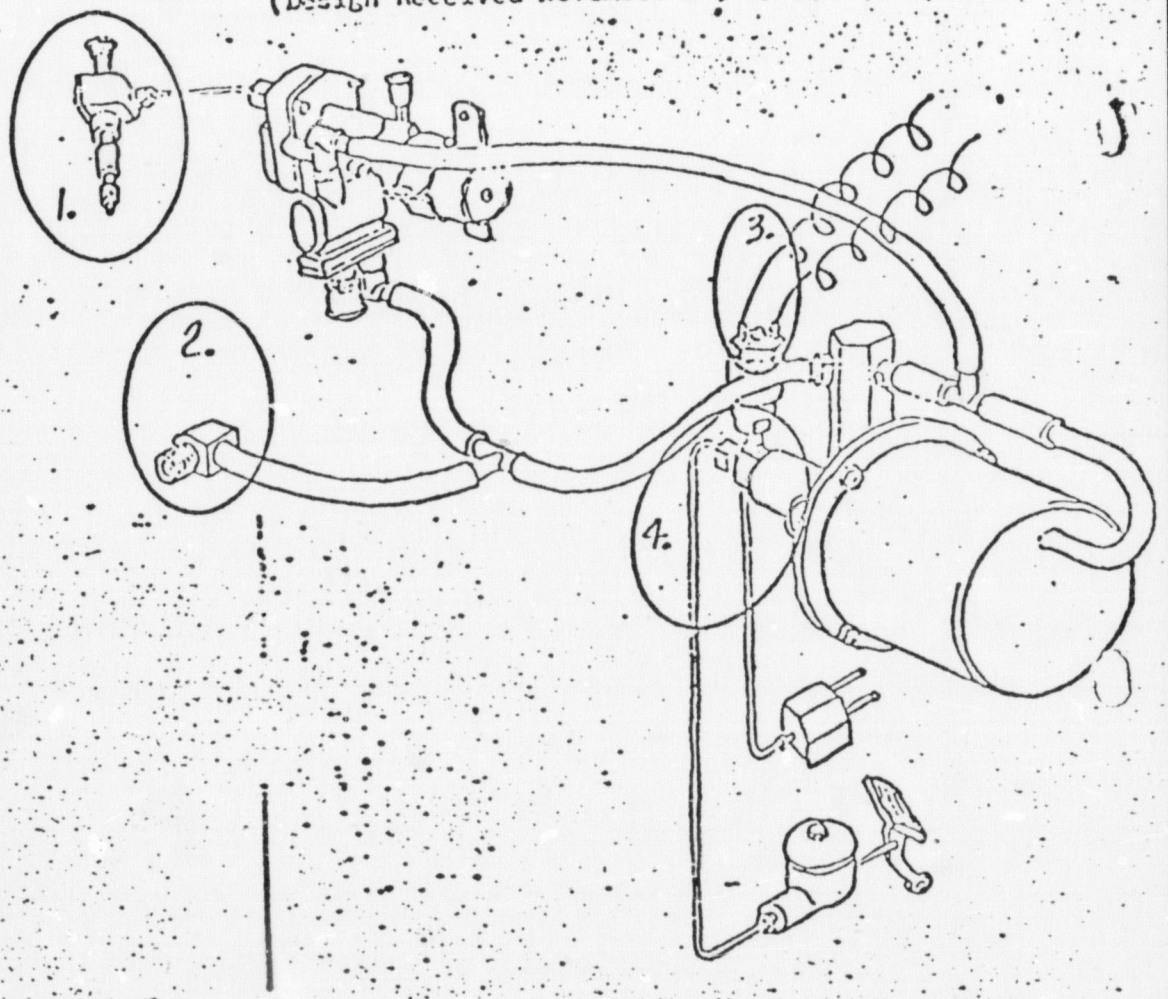
Fig. (3) The check valve shown provides an escape for trapped fluid thereby insuring positive sealing of the Delrin seat and the cone plug during each cycle.

THIS STATEMENT IS FALSE


NEW DESIGN
Both
FROM MASTER CYLINDER
FROM MASTER CYLINDER
TO HYDRAULIC PRESSURE SWITCH
FROM VEHICLE'S WHEEL CYLINDERS
TO HYDRAULIC PRESSURE SWITCH
TO VEHICLE'S WHEEL CYLINDERS

November 8, 1965

GENERAL ANALYSIS OF FAIL-SAFE TRANSFER VALVE CONCEPT
(Design Received November 10, 1965)




Anti-Skid hook-ups to any vehicle

1. Mechanical - to speedometer cable output
2. Vacuum Supply - to intake manifold
3. Electrical - to car battery supply
4. Hydraulic - into brake lines - between master cylinder and wheels

If failure occurs in items 1, 2, 3, or 4, or any combination thereof, item 4 must function when called upon (i.e. to revert to original system).

Therefore, for fail-safe condition, if any failure occurs in anti-skid unit, unit must be by-passed or some other device must be added to provide equivalent to or better than original equipment braking power.

Of the many failures or malfunctions that may occur, or any combination thereof, some will be fail-safe and others will be <u>non</u> fail-safe.

November 10, 1965

GENERAL ANALYSIS OF FAIL-SAFE TRANSFER VALVE CONCEPT
(Design Received November 10, 1965)

[DX 529, P 101]

MECHANICAL HOOK-UP

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| Cable stops rotating (cable stops any or all gear teeth sheared, broken cable, broken shafts, broken connections) | Governor will not turn, cam gear will not actuate | Fail-safe | Unit will not function, normal brakes available | |
| Cable rotates erratically (rusted cable, some gear teeth missing or not properly meshed, worn or loose connections) | Governor will rotate erratically | Non Fail-safe | Unit may produce lags at any speed | Corrects condition by applying vacuum to front chamber of Servac allowing spring to return piston, thereby reapplying brake pressure. Pressure output depends on spring force and is limited to approximately 500 p.s.i. |
| Cam gear hangs up | Microswitch remains closed, thereby closing the solenoid ground circuit. Solenoid will retract on normal stops as soon as brakes are applied | Non Fail-safe | Lags may occur at low speeds, and/or rotary valve will remain open. This will occur until the cam gear is released or pressure switch is opened | Same as above (May cause a problem on steep grades) |
| Rotary valve jammed in open position | Vacuum to rear of can at all times | Non Fail-safe | Solenoid may or may not be forceful enough to return rotary valve to closed position | Same as above |

[DX 529, P 101]

E-1189

[DX 529, p 11]

PNEUMATIC HOOK-UP (contd.)

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| Failure of Ferra-Vac Spring to retain spring rate or fracture of coil | Loss of brake pressure | Non Fail-safe | Failure unlikely | Would not correct |



[DX 529, p 11]

VACUUM HOOK-UP

[DX 529, p 121]

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| Vacuum failure - complete (stalled engine) (Disconnected or cut hose from source to can or to sensing unit; kinked hose from source to tee during cycling) | No vacuum to can or sensing unit | Non Fail-safe | Unit will stop cycling and output will depend upon can's spring holding force | Modified piston and check valve does not attain original brake pressure unless driver releases brake pressure slightly and reapplies pressure |
| | Residual vacuum to can or sensing unit | Non Fail-safe | Partial cycle | In approximately .5 sec. atmospheric pressure would leak into both chambers returning piston. Output pressure as stated above |
| Hose - kinked or cut between tee and transfer valve | No vacuum to front of can (resembles original design less transfer valve) | Non Fail-safe | Unit will cycle, output depends upon can's spring | Does not correct unless driver releases pressure as stated above |
| | | | If rotary valve is jammed, piston would remain withdrawn with no brake pressure | System remains in reduced braking pressure state. NOT FAIL-SAFE |
| "Low" source vacuum | Displacement may be less than minimum or piston does not move at all | Non Fail-safe | Unit will cycle but lags will occur. Ref. - Displacement tests | Applies vacuum to front chamber of Ferro-Vac allowing spring to return piston, thereby reapplying brake pressure Output as stated above |

[DX 529, p 121]

E-1191

VACUUM HOOK-UP (contd.)

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| Kinked hose from tee to sensing unit, kinked hose from sensing unit to rear of can | No vacuum to sensing unit and to back of can | Fail-safe | Unit will not cycle but spring and vacuum to front of can will maintain output | |
| Transfer valve stuck in down position (vacuum) (Piston normally forward) | Vacuum to both front and rear of can | Non Fail-safe | Unit will tend to balance out, output will depend upon spring | Output would still depend on spring if valve got stuck after unit pulsed. If it were stuck before unit pulsed, it would fail safe |
| Transfer valve stuck in up position (air) (Piston back) | Vacuum to back of can but not to front (resembles original design) | Non Fail-safe | Unit will cycle, output will depend upon can's spring | Output would still depend on spring for therefore it does not fail-safe. This condition would result no brakes if the rot valve remained open. Reliability would depend on transfer v |
| Clogged large air filter on sensing unit | No air pressure to back of can | Non Fail-safe | No brake pressure | Pressure would depen on spring (momentari .5 sec.) |
| Clogged large air filter on transfer valve | No air pressure to front of can | Non Fail-safe | Pressure output depends on spring | Fail-safe with higher output |

[DX 529, p 13]

[DX 529, p 13]

E-1192

[DX 529, P 141]

ELECTRICAL HOOK-UP

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| Pressure switch short | After first contact made of microswitch, solenoid will remain energized | Non Fail-safe | Lag and/or repeated cycling at lower speeds | Applies vacuum to front chamber of Ferro-Vac allowing spring to return piston, thereby reapplying brake pressu Pressure depends on spring |
| Microswitch jammed in open position | Initial contact cannot be made | Fail-safe | Solenoid will not energize | |
| Microswitch jammed in closed position | After initial contact, solenoid will remain energized. Pressure Switch will not function properly | Non Fail-safe | Solenoid will not release until pressure switch is open | Same as above. (May cause a problem on steep grades) |

[DX 529, P 141]

IDX 529, p 151

HYDRAULIC HOOK-UP

| Failure | Result | Fail-safe or Non | Remarks | What does Fail-safe Transfer Valve and Check-off Modification do to Correct |
|---|---|---|---|---|
| "O" Ring seal broken | Loss of output and of fluid | Non Fail-safe | Continued loss of fluid will result in loss of brakes. | Will not correct |
| Check valve jams open | Pedal height will decrease as piston goes back | Fail safe if hydraulic oil reservoir is sufficient. Non Fail-safe if it is not, or if one check valve jams open on dual unit | If reserve is sufficient (on single) result will be locked wheels. On dual, loss of brakes on one set | Will not correct<br>Will not correct |
| Check valve jams closed | Fluid becomes trapped in unit's system | Fail-safe | Unit will function normally | |
| | After initial run, fluid will not return to reservoir | Fail-safe | Wheels may be locked. If vacuum source is off, output will depend on spring. If source is on, higher output results | |

IDX 529, p 151

E-1194

November 10, 1965.

EFENDANT'S EXHIBIT 529A

FAIL-SAFE ANALYSIS OF PISTON AND CHECK VALVE MODIFICATIONS

| ilures Resulting in Loss or Reduction of Brake Power | * Probability of Failure Occurring and General Comments |
|---|---|
| A vacuum failure to entire system or to front of Perma-Vac during cycling would result in a reduced pressure availability unless the driver releases his foot pressure slightly and re-applies pressure. This must be done to seat the cone plug. | 1. Engine stallout has occurred during road testing on numerous occasions. Vacuum failures and drops can be expected during high speed panic stops on most vehicles. |
| Clogging of escape passage for trapped fluid would prevent seating of cone plug. | 2. Depends on size of hole. |
| Leakage past "O" ring around delrin seat would prevent seating of cone plug. | 3. Unlikely. |
| Delrin seat may not stand up under repeated use resulting in leaks. | 4. Must assume this will happen until test data indicates otherwise. |
| Leaky gasket. | 5. Unlikely. |

D-529A

* An opinion stated without the benefit of test data

E-1195

DEFENDANT'S EXHIBIT 530 [DX 530, p 1]

SINGER

30 ROCKEFELLER PLAZA • NEW YORK 20, N.Y.

# MEMORANDUM

SINGER CONFIDENTIAL

TO: Mr. A. di Scipio

FROM: Perma Anti-Skid Control Task Force

DATE: November 18, 1965 REFER TO:

SUBJECT: PERMA ANTI-SKID CONTROL - RECOMMENDED COURSE OF ACTION

This memorandum presents the second report of the Perma Anti-Skid Control Task Force. In our first report we recommended to CFD management that the marketing effort be temporarily suspended and the units in the field be withdrawn because of the heavy legal exposure faced by Singer. The withdrawal program has moved along rapidly and this exposure has been reduced substantially.

In this report we recommend to CFD management that Singer enter a program for divesting itself of this product, recovering as much as possible of our investment. The following portions of the memorandum present:

1. a brief review of the background of this problem
2. the reasons for the Task Force's recommendation
3. a plan for implementing the recommendation

## BACKGROUND

The first sketchy reports received after CFD became responsible for the Perma Anti-Skid Control program indicated that this program, in which Singer has invested nearly $2 million, might be in serious trouble. First, reports of technical shortcomings in units already on cars suggested that Singer might be faced with serious legal exposure. Second, failure of a redesigned unit to perform properly during a demonstration for CFD management cast doubt on plans, which were already under way, to make commitments for an enlarged marketing program. (This degree of unreliability is critical in a product which is sold as a safety device and affects the life of the occupants of a car.)

In view of the above, you appointed a Task Force to make a comprehensive study of this program in order to (1) determine whether any immediate action was required regarding units in the field, and (2) develop a recommended course of action for CFD management. The study

D.P.E. 530

EXH. NO. 56 A&B
DONAK, REPORTER

BACKGROUND (continued)

was to cover the technical validity of the product, the implications of using Singer's name, the legal aspects--product liability and our contracts with Perma and with our distributors, the financial status of the program, and the possibilities for divestiture.

The initial findings of the Task Force confirmed the fact that there were technical deficiencies in the product and that Singer's exposure was heavy. Thus the withdrawal program, estimated to cost about $250,000, was recommended and undertaken. Field reports received during withdrawal confirmed the need for such a program. The more costly action of withdrawal of units rather than replacement with redesigned units was recommended because the date when a proven, redesigned unit would be available was indefinite.

The issue now facing CPD management--deciding on a future course of action for this program--is a difficult one because of the $2 million already put into it. Almost half of this amount, or $1 million, is in inventory tied to the present design. Four alternative courses of action are open to CPD management:

1. Make further investments in the product to bring it to a point, technically, where Singer can make and market it.

2. Turn to Perma for recovery of our damages in the program.

3. Try to divest ourselves of the program, recouping as much as possible of our investment.

4. Terminate the program and write it off.

REASONS FOR RECOMMENDATION

From our analysis and evaluation, the Task Force recommends that CPD begin immediately to look for a means of divestiture for this program because: (1) if Singer is to continue the program, the probability that major additional investments will need to be made is high and the chance of recovering the total investment in the marketplace is low; and (2) our recourse to recovery of investment from Perma is very limited. Should divestiture prove impossible, we would then recommend writing off the program.

High Investment - Low Chance of Recovery

The Perma Anti-Skid Control unit is not ready for the market. This conclusion is reached in technical evaluations from both the Elizabeth Engineering staff and from the Research and Development Division. From

High Investment - Low Chances of Recovery (continued)

a technical and marketability standpoint there are three major areas of deficiencies:

1. The present design is not fail-safe; that is, should the unit fail, it could lead to a significant reduction in or complete loss of the normal braking capabilities of the car. This deficiency is of critical importance because: (a) Singer's corporate counsel advises that by not being fail-safe the product greatly increases Singer's legal exposure; (b) Singer's Insurance Department advises that Singer could not obtain product liability insurance if we knowingly sold a product that, owing to inherent defects, could cause an accident; (c) specifications established by some of the automotive companies require that an anti-skid unit be fail-safe; and (d) the damage to Singer's quality reputation on its other products could be severe in the event of publicity stemming from a lawsuit where this design deficiency was brought out.

2. The present design has several operational deficiencies. The ones of most concern are: (a) when the car engine stalls during a panic stop, there is loss of vacuum and brake line pressures do not reach design specifications; (b) the mechanisms of the system are such that at slow speeds the available vacuum can drop below required levels causing a slight lag in operation; and (c) it is possible to "fool the unit" - that is, the brakes can be applied gently on icy roads and result in a skid without activating the unit.

3. Reliability testing of the components and of the total unit is far from complete. Some bench endurance tests have been performed, but compared to the level of testing that should go into a unit that affects the basic safety of a car, there are major shortcomings. The unit has not been field tested (1) on ice and snow, (2) at speeds below 30 m.p.h., (3) under varying environments, such as extremes of low temperatures and high temperatures, dust and freezing rain, (4) at high altitude, (5) on long downgrades, (6) under varying car loads, (7) on cars where motor maintenance is poor, and (8) over extended mileages.

Elizabeth engineers estimate a program to resolve the operational deficiencies (not the fail-safe problem) and to provide adequate testing may require up to one year and $300,000. This design period could easily be extended in time and the cost increased to $750,000 - $1,000,000 owing to the nature of development work and to the continually changing design criteria. Disc brakes are now appearing on a number of new cars;

PERMA ANTI-SKID CONTROL -
RECOMMENDED COURSE OF ACTION

Page - 4

High Investment - Low Chance of Recovery (continued)

the Perma unit is not now designed for disc brakes. Front-wheel drives have appeared on the scene; the unit is not designed to operate with front-wheel drives. Also, the unit is not designed to operate on cars with gear shifts or on cars with front-wheel takeoffs for the speedometer.

While the added investment is high, the probability of recovering the investment is low. A pro forma income statement has not been prepared because the design, and thus the manufacturing cost, is still changing. However, these factors are working against Singer: (1) the additional design and engineering time plus the added investment can add two years to the breakeven point given on this project at the outset of the program, moving it from the end of 1967 to the end of 1969; (2) under the impetus of Government interest and threatened legislation, the auto companies are bound to be working on similar or competitive approaches; and (3) our Patent counsel advises that the Perma patent application, which covers the unit in its present form, is not broad enough to preclude "designing around it".

In addition to the risk of not recovering our investment in the Perma product, there is the undesirability of venturing into a business that is foreign to Singer. One product does not make a product line, and the automotive parts business is not an attractive one for Singer.

Heavy investments in engineering staffs and automotive testing facilities would be required to compete in the industry. Even with this investment, it is doubtful whether a controlling position could be attained because of the purchasing power and engineering skills of the Big Three.

Recourse to Perma Limited

While there is a reasonable chance that Singer might legally have recourse to Perma in order to recover the damages from this venture, the latest Dun & Bradstreet Report shows that Perma has a negative net worth and essentially no assets.

ACTION PLAN

To implement our recommendation, the following action steps are proposed:

1. Arrange with Kelsey-Hayes to test our unit. This manufacturer of braking systems has evidenced interest in such tests since initial engineering discussions last March. Singer would expect to gain from these tests: (a) technical discussions and appraisal from automotive engineers; (b) an indication

PERMA ANTI-SKID CONTROL -
RECOMMENDED COURSE OF ACTION



ACTION PLAN (continued)

of the extent of Kelsey-Hayes' interest; and (c) additional performance data on the present design. Prior to any testing we would arrange for a written agreement on their disclosure of results to us and on their holding all information for internal use only.

2. Work with the Corporate Development Office to develop a specific strategy for divestiture. This strategy would include a list of prospective buyers in order of priority, that we would like to get in a sale, and alternative terms of payment.

3. Meet with Mr. Walter Byers to determine what assistance he might provide.

4. Continue to meet with Perma executives in an effort to improve the terms of the contract. The reversion clause and royalty payments in our agreement with Perma detract from any package we might offer.

The reversion clause requires that beginning in 1966 Singer incur expenses of $100,000 per year in promoting the device; if not, Perma can reacquire the patent rights by paying certain specified sums of money. The royalty schedule briefly is:

a. Sales other than b and c below -

1. None on the first 15,000 units
2. $10 per unit on the next 20,000 units
3. Above 35,000 units, 10% of factory price for 5 years
4. 5% for the succeeding 5 years

b. Sales to O.E.M. -

1. 5% of factory price for 10 years

c. Sales to manufacturing licensees of Singer for resale -

1. Royalty-free except as to O.E.M., in which case 2½% of royalties received by Singer.

PERMA ANTI-SKID CONTROL -
RECOMMENDED COURSE OF ACTION



ACTION PLAN (continued)

We would like to eliminate the reversion clause and replace the royalty schedule with a revised schedule that would recover Singer's investment first and then share any proceeds with Perma.

Original Signed by
H. C. Person

HCP:lk
cc: Messrs. S. Dorius
C. W. Drucker
R. H. Elman
J. E. McConnaughy
D. McKeeman

DEFENDANT'S EXHIBIT 577 (EXCLUDING APPENDICES)

TECHNICAL STATUS REPORT

"PERMA ANTI-SKID DEVICE"

DPE 577

ED 999(6/64)

SINGER
321 FIRST STREET · ELIZABETH, N. J.

MEMORANDUM

TO: Mr. R. A. Kloby - Manufacturing Manager
Perma Anti-Skid Device

FROM: A. E. Romel

DATE: July 22, 1965

REFER TO: AER:ms

SUBJECT: TECHNICAL STATUS REPORT
"PERMA ANTI-SKID DEVICE"

The attached technical status report is submitted for your review, comments, and approval. It should be noted that only the major highlights of the project are contained in the report. Detail information concerning development, laboratory, and road testing is on file in this office should you desire more information.

An oscillograph tape recording taken on a 1965 Cadillac during a 40 m.p.h.panic stop on dry pavement is included in the appendix. This tape illustrates the type of "lag" mentioned in the report which causes brake power reduction. It is hoped that these tapes will enable us to determine the cause of such lags and redesign to eliminate them entirely.

Respectfully submitted,

A. E. Romel

A. E. Romel, Manager
Manufacturing Engineering

# TECHNICAL STATUS REPORT

# "PERMA ANTI-SKID DEVICE"

Prepared by

A. E. Romel

Manufacturing Engineering

The Singer Company

Elizabeth Factory

July 22, 1965

E-1204

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A. Field Complaint Reports
B. Graphs Of Stopping Distance Versus Speed
C. Performance Testing Summary Sheets
D. Oscillograph Tape Recording

I. HISTORY

1. Reason for changing original design.

A. Field complaints.

Numerous field complaints, written and verbal, began to generate from the field during the month of January 1965. Although a majority of these complaints involved situations which pertained to installation and servicing problems, performance and reliability deficiencies appeared as early as January 15, 1965. Investigations conducted by our engineering staff while servicing these complaints indicated that the pressure switches were not performing properly. The feasibility of requiring different switch settings for each make and/or model vehicle was investigated, and reliability, repeatability, and environmental testing was conducted. The results of these tests indicated that the pressure switches were unreliable, and therefore the decision to stop production and marketing of the unit was made.

On March 12, 1965, the engineering department received copies of preliminary specifications for Anti-Skid Devices from Perma. These specifications were developed by the Cadillac Division of General Motors, and were dated July 27, 1964. A report from the Du Pont Corporation was received on March 11, 1965, which contained an engineering evaluation of the unit along with a list of features that indicated the basic design concepts of the unit were deficient.

An analysis of these reports along with information obtained during a discussion with various brake and automotive manufacturers, showed that certain design aspects had to be changed, because of possible brake failure, or insufficient brake pressure.

B. Production and performance testing.

Due to a large number of rejects appearing during manufacturing, an evaluation of the test specifications supplied by Perma was conducted. An analysis of these specifications and their relation to actual product performance in a vehicle was started. Tests performed on company cars and laboratory test equipment indicated that the unit

did not react the same on all types of vehicles, even though they met the laboratory tests. Investigations by Singer and Perma, revealed that fluid displacement requirements were greater on the later model vehicles than they were on the older models, which were used by Perma during development. The available displacement was marginal for most of the newer make vehicles, which caused complete or partial brake failure.

The development of a new pressure switch and redesign of the hydraulic system of the unit were carried out simultaneously. The solution to the pressure and displacement problems was to add a vacuum assist by means of a transfer valve and to increase the piston bore size. Extensive road tests were conducted on a redesigned unit during April 1965. Analysis of the test data indicated that longer stopping distances occurred when the device was used. These distances were increased by as much as 20% on dry pavement when the device was used. Due to the lack of a test vehicle for the dual unit, the system was tested on a single master cylinder vehicle. These results were mixed with a maximum increase of 14% on dry pavement.

On May 6, 1965 the engineering department recommended that the shipment and sale of units be held up until a unit could be developed, which would provide equal or shorter stopping distances.

Plotted data of cycles/sec. vs. stopping distances taken during these tests, indicated that it was theoretically possible to obtain these results by:

1. Increasing the number of cycles/sec.
2. Cutting down the degree of wheel rotation during the release portion of the cycle.

2. Product Redesign Alternatives.

A. Initially (before first series of road tests)

a. Pressure Switch

1. Improve present design by altering a minimum of components.
2. Buy a commercial switch which met the requirements.

b. Perma-vac (Hydraulic System)

Alternate solutions to displacement and low pressure out-put problems.

1. Complete redesign of unit.

2. Addition of vacuum assist.

B. Alternate solutions to longer stopping distance problem (After May 6, 1965).

a. Increasing vacuum flow by increasing passages in sensing unit.

b. Meter brake line pressure by means of a control valve.

c. Meter vacuum flow-thru sensing unit.

d. Meter vacuum flow by means of a four-way transfer valve.

e. Electrical cycling of sensing unit through use of a solenoid.

f. Electrical cycling by means of a governor generator.

g. Solenoid operated four-way valve.

h. Servo metering of vacuum.

i. Pressure metering by using two relay controlled switches.

j. Pressure metering by using two different pressure switch settings.

3. Reasons for selection or rejection of alternatives.

The alternatives were first classified into short and long range projects. Due to the cost and limited personnel available, it was decided to restrict extensive experimentation to short range projects. Some preliminary investigations were to be performed on the long range projects, in the event that the desired results were not obtained.

Alternatives b, d, i, and, j were considered as short term projects. Alternate "j" was rejected in that, it would require the operator of the vehicle, to throw a switch for each specific road condition encountered. It was considered undesirable from a marketing viewpoint. Similarly, "i" presented a problem when driving on mixed road conditions. Preliminary investigations conducted on alternate "d" were not encouraging, and therefore, it was shelved.

The metering of brake line pressure appeared to be the least costly, had shortest lead time, and reduced stopping distances during preliminary testing.

Preliminary investigations were performed on all the long range projects except "h". Further studies must be made before reaching any conclusion, in that the tests conducted, were rather limited.

It should be noted that the pressure switch has been redesigned, and is functioning adequately. The low pressure out-put problem has been overcome, except for the case where engine stalling might occur. The question of stopping distances is fully discussed in the next section.

## II. PERFORMANCE CRITERIA

1. Operating Range

A. Dual Unit

The unit is designed to cycle within the following ranges when braking is applied abruptly and both rear wheels lock-up.

1. Temperature: 200°F to -30°F (*)
2. Speed:
   a. Maximum: 70 m.p.h. (**)
   b. Minimum: 10 m.p.h.
3. Cycles per second: 2 to 3
4. Minumum Vacuum: 14 in. Hg. and an excess of 12 cu. ft. per minute in volume of vacuum.
5. Minimum Voltage: 11 Volts D.C.
6. Fluid Displacement: .330 cu. in.

B. Single Unit

The unit is designed to cycle within the following ranges when braking is applied abruptly and both rear wheels lock-up.

1. Temperature: 200°F to -30°F (*)
2. Speed:
   a. Maximum: 70 m.p.h. (**)
   b. Minimum: 10 m.p.h.
3. Cycles per second: 2
4. Minumum Vacuum: 14 in. Hg. and an excess of 12 cu. ft. per minute in volume of vacuum.
5. Minimum Voltage: 11 Volts D.C.
6. Fluid Displacement: .435 cu. in.

(**) Vehicles have not been tested over this speed.

(*) This information is based on tests conducted by Perma. Environmental tests at this temperature have been performed in a laboratory.

2. Application Requirements

A. Vehicles must have:

1. Hydraulic operating drum type brakes.

2. 12 Volt D.C. electrical system.

3. Speedometer drive at transmission.

4. Rear wheel drive.

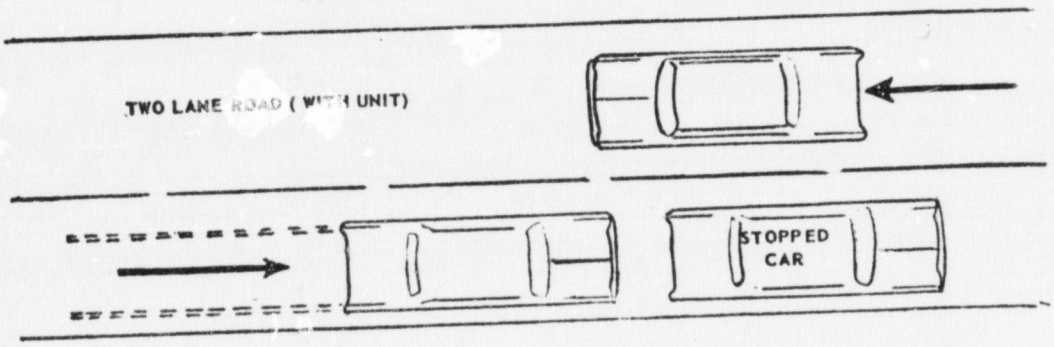
5. Internal combustion engine which creates a minimum of 15 in. of vacuum and an excess of 12 cu. ft. per minute in volume of vacuum. Engine must be in good operating condition to insure sufficient engine vacuum supply.

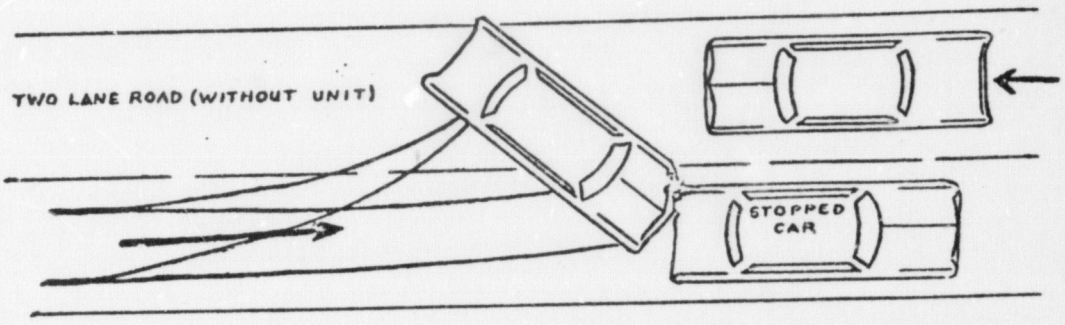
6. Vehicle brake system must be in good condition, properly adjusted, and bled.

3. Limitations of Unit

A. Steering Control

1. When stopping the vehicle on two lane roads where straight stopping is essential, the unit enables the operator to stop the vehicle within 0 to 5° with respect to the road.






The degree of steering control obtainable is dependent on road coefficient of friction and speed. It is possible to avoid contact with an object in the path of the vehicle, depending on its location and the other variables mentioned.

The unit will not provide steering control under conditions where: steering control would not be available even without brakes being applied, due to extremely low road friction; centrifugal skids due to excessive high speeds on sharp curves or high acceleration on slippery roads.

2. On mixed road conditions, two right wheels on snow or ice, and two left wheels on dry pavement, the unit will enable the operator to bring the vehicle to rest at an angle of 0-5° with respect to the road, depending on the amount of correction introduced by the operator.

B. Stopping Distances with Unit

1. Dry Road Conditions

Latest test results indicate that the average stopping distance varies with make of vehicle. Tests conducted on a 1965 Cadillac, 1964 Buick Wildcat and 1964 Dodge Polara indicated that:

1. Slightly longer distances can be expected on the Cadillac for all speeds.

2. Shorter distances can be expected on the Buick for speeds over 40 m.p.h.

3. Shorter distances can be expected on the Dodge for speeds over 50 m.p.h. with equal or slightly longer distances for the lower speeds.

A summary of average stopping distances for these vehicles is provided below. Please note that two different test sites were used for the Cadillac tests. The Route 80 tests were not considered in the averages because, a limited number of runs were made. The results were much better, and it should be pointed out, that these tests were conducted when the vehicle was new.

| VEHICLE MAKE | SPEED | TEST SITE | AVERAGE STOPPING DISTANCE (FEET) FOR DRY ROAD WITH DEVICE | WITHOUT DEVICE |
|---|---|---|---|---|
| 1965 Cadillac (Dual Unit) | 30 | Rt.I-287 | 49' 5" | 48' 1" |
| | 40 | Rt.I-287 | 79' 5" | 77' 10" |
| | 50 | Rt.I-287 | 123' 4" | 122' 3" |
| | 60 | Rt. 80 | 167' 9" | 181' 6" |
| | 60 | Rt.I-287 | 173' 2" | 170' 7" |
| | 70 | Rt. 80 | 217' 5" | 231' 3" |
| | 70 | Rt.I-287 | 235' 1" | 233' 3" |
| 1964 Buick (Single Unit) With Metering Valve | 30 | Rt.I-287 | 39' 11" | 39' 5" |
| | 50 | Rt.I-287 | 105' 10" | 107' 3" |
| | 70 | Rt.I-287 | 195' 5" | 198' 8" |
| 1964 Dodge (Single Unit) With Metering Valve | 30 | Rt.I-287 | 42' 11" | 41' 7" |
| | 50 | Rt.I-287 | 113' 11" | 112' 5" |
| | 70 | Rt.I-287 | 219' 2" | 222' 10" |

2. Wet Road Conditions

Tests conducted on the above vehicles indicated that the average stopping distance was substantially shorter for speeds over 40 m.p.h. when the device was used on the Cadillac and Buick. Slightly longer distances were obtained below this speed for

these vehicles. The Cadillac was retested at 30 m.p.h. after the engine was retimed and tuned. This test resulted in shorter stopping distances with the unit. The graph in the appendix was not changed to reflect these results. Substantially shorter distances were obtained for all speeds on the Dodge with the exception of 30 m.p.h. tests, which were equal. The following is a summary of these tests.

| VEHICLE MAKE | SPEED | TEST SITE | AVERAGE STOPPING DISTANCE (FEET) FOR WET ROAD WITH DEVICE | WITHOUT DEVICE |
|---|---|---|---|---|
| Cadillac | 30 | Rt.I-287 | 61' 4" | 64' 1" |
| | 40 | Rt.I-287 | 95' 9" | 96' 9" |
| | 50 | Rt.I-287 | 168' 11" | 177' |
| | 60 | Rt.I-287 | 226' 9" | 243' 4" |
| | 70 | Rt.I-287 | 325' 4" | 354' 8" |
| Buick | 30 | Rt.I-287 | 41' 11" | 40' 10" |
| | 40 | Rt.I-287 | 78' 1" | 78' 11" |
| | 50 | Rt.I-287 | 126' | 132' 10" |
| | 70 | Rt.I-287 | 283' 5" | 305' 4" |
| Dodge | 30 | Rt.I-287 | 46' 3" | 46' 11" |
| | 50 | Rt.I-287 | 152' 8" | 164' 1" |
| | 70 | Rt.I-287 | 365' 7" | 414' 4" |

Graphs of average stopping distances versus speed for dry and wet road conditions can be found in the appendix of this report. Detailed summary sheets listing all runs made are also included.

C. Ability to Cycle

1. Fooling the unit

It is possible under certain conditions to lock-up the wheels without cycling the unit. This characteristic is termed "fooling the unit". As stated previously, the brakes must be applied abruptly in order to trip the micro switch in the sensing unit. This abrupt braking action is generally applied during emergency stops. However, drivers have been told to apply brakes slowly on slippery road conditions to avoid wheel lock-up. This is practiced by most experienced drivers, and therefore, they must be informed that the unit will not cycle under these circumstances.

2. Loss of vacuum

The unit will not cycle if the vehicle stalls or a loss of vacuum to the unit occurs, due to hose breakage, or excessive leakage in the vacuum system of the unit. If the loss of vacuum occurs before the brakes are applied or during a cycle, a loss of braking power will result. The calculated available pressure, disregarding friction is: 450 p.s.i. for a single piston unit, and 485 p.s.i. for a dual unit. This pressure may or may not lock-up the wheels, depending on the speed and condition of the brake linings at the time the failure occurs.

Tests performed on a 1965 Cadillac (Calais) at 60 m.p.h. on dry concrete, revealed that: when the motor was turned off prior to braking, 450 p.s.i. was developed. The vehicle stopped in the same distance as it did without a unit. With the motor turned off during cycling, 550 to 600 p.s.i. was observed, with approximately a 10 ft. decrease in stopping distance.

3. The nature of the product although seemingly simple in principle requires that qualified installation and servicing be provided to the consumer. Therefore, we feel a trouble shooting and repair guide must be supplied.

The following guide is an example of the type of information which will be included in a technical servicing manual.

## TROUBLE SHOOTING AND REPAIR

| | SYMPTOM | PROBABLE CAUSE | CORRECTIVE ACTION |
|---|---|---|---|
| 1. | Anti-Skid Unit not operating, speedometer working | Flexible shaft not installed correctly to gear box or sensing unit | Check installation of flexible shaft by:<br>1. Raise rear wheels and put in drive<br>2. Place drop light behind sensing unit and observe whether governor shaft is turning |
| | | Open connection in wiring | Check wiring to see that all connections are secure |
| | | Insufficient voltage applied to pressure switch | Check 12 volt source with volt meter |
| | | Hoses connected wrong, disconnected or damaged | Check connection, reconnect or replace damaged hose |
| | | Stripped gears in gear box | Replace gear box |
| 2. | Speedometer not operating; Skid Unit operating | Speedometer cable connection broken or not properly installed | Check installation and replace broken parts |
| 3. | Speedometer not operating; Skid Unit not operating | Stripped speed-o-gear on adapter or gear slipping on insert | Replace adapter using gear that has the same number of teeth |
| 4. | Hard brake pedal, no braking pressure | Hoses connected wrong | Check installation sheet for correct installation of hoses |

| | SYMPTOM | PROBABLE CAUSE | CORRECTIVE ACTION |
|---|---|---|---|
| | | Hydraulic pressure switch leaking internally causing contacts to short out | Replace switch |
| 5. | Anti-Skid modulating continuously | Solenoid of Anti-Skid grounding out | Replace with new sensing unit |
| 6. | Long lag time between last pulse of Anti-Skid sensing unit | Hydraulic pressure switch set too low | Replace switch and return defective switch to factory |
| | OR | | |
| | Reduce brake pressure at the end of pulses of panic stop | Transfer valve sticking in closed vacuum port position | Replace Perma-vac and return unit to factory for evaluation |
| 7. | Unit pulsing very slowly | Lack of proper operating vacuum supply or excessive vacuum leakage | Check carburetor adjustments, distributor timing with vacuum gage. Although the unit will operate with 16 in. Hg., it is recommended that 18-22 in. Hg. be used due to possible losses during cycling |
| 8. | Anti-Skid Unit not operating, motor stalling | Lack of proper operating vacuum | Same as above |
| | | Improper engine idle | Same as above |
| | | Automatic transmission dashpot not operating properly | Adjust dashpot |

| | SYMPTOM | PROBABLE CAUSE | CORRECTIVE ACTION |
|---|---|---|---|
| 9. | Erratic braking, intermittent pulsing of Anti-Skid unit in panic stop | Worn speed-o-gear | Replace gear |
| | | Braking system not bled properly | Bleed brakes |
| | | Improper brake adjustment | Adjust brakes |
| | | Glazed brake lining, worn brake lining or leaking wheel cylinders | Use standard auto repair procedure |
| 10. | Anti-Skid Unit cuts out on slippery road conditions | Hydraulic pressure switch set too high | Replace switch and return to factory |

## III. FUTURE (SHORT RANGE) PROGRAM

1. Aim of present testing program.

The present testing program is designed to obtain, technical information on unit performance, to evaluate its reliability, and insure that adequate product testing at the factory is provided.

Vacuum drops at the end of cycling a unit, on a vehicle, have been detected through the use of an oscillograph recorder. We are presently investigating the cause of these vacuum drops, which result in lags during cycling, and longer stopping distances. These lags appear occasionally, and would not, in most cases be noticed by the average consumer. They are, from an engineering standpoint, highly undesirable.

Another area of investigation is the hydraulic metering valve. Information on its effect on brake pressure reaction time is being obtained, to determine whether higher pressure switch settings are feasible. Technical data for slippery conditions must also be obtained to insure unit cycling on snow and ice. These tests will be conducted once the lagging problem is overcome.

Performance testing should be carried out on a variety of vehicles, due to the difference in displacement requirements. We have started this program on a limited basis, in that obtaining test vehicles, is difficult.

2. Performance indications to date.

There are strong indications that trouble free performance has not been obtained with the present configuration. Even though shorter stopping distances have been obtained in most test runs, occasional lagging is still present. However, we are very optimistic now that we are able to record data by dynamic testing. The oscillograph has taken out the guess work, and a logical approach to design problems can be taken.

3. Problem areas.

a. Design problems which may prevent sale or make undesirable.

1. The maximum available hydraulic pressure with no vacuum is only 450 p.s.i. and 485 p.s.i. for the single and dual units

respectively. Wheel lock-up on dry pavement is approximately 400 to 800 p.s.i. for most vehicles. This means that if the engine stalls, loss of brake power could result.

2. The dual unit requires a minimum of 14 in. Hg. vacuum during the last pulse to prevent lagging. Tests on the single unit have not been completed to date, but we suspect that the requirement will be about the same. Vacuum drops as low as 11 in. Hg. have been detected on a 1965 Cadillac. We are presently checking out this vehicle to determine whether engine performance is the cause. If engine vacuum drops of these kinds are typical in the industry, the unit must be redesigned. The Cadillac specification mentioned before, specified that the unit should function with a minimum of 7 in. Hg.

b. Design problems affecting product life and reliability.

Sensing Unit

1. Contamination of drive and cam gear housing has been discovered by road and laboratory test methods. This condition causes premature wear of electrical contacts, cam gear hang-up, and shorting out of the electrical circuit. The electrical malfunctions prevent the unit from cycling, but do not affect the normal braking system. Cam gear hang-up would cause the unit to cycle during normal stops, or when trying to hold a vehicle on a hill if the drive train was broken at this time. We have not encountered both malfunctions occurring at the same time in any of the many road tests performed. A retaining washer has been added to restrict the entrance of foreign matter. We have accumulated approximately 36,000 miles for an operating speed of 65 m.p.h. on our test runs to date. The unit has been operated continually for 8 hrs. daily with checks for cycling being taken periodically.

2. Contamination entering rotary valve through air filters can cause total brake failure. We have experienced this on one of the test vehicles. However, new specifications have been developed for the filters which should afford the required protection. Our field servicing manual will specify that, "filters must be changed every 5,000 miles or six months, whichever comes first".

3. Centrifugal action and heat generated at high speeds have a tendency to drain or dry out lubricants on the reverse switch components. Some parts have been noted to wear completely through breaking the electrical circuit. Expected life of these components is approximately 40,000 miles for operating speeds of 65 m.p.h. Failure of these components should prevent unit from cycling.

Perma-vac Unit

1. Vacuum failure or stalling of engine results in reduction of braking power.

2. Metal chips or foreign matter in hydraulic system, cuts "O" rings and results in loss or reduction of brake power. This is a quality control problem but is mentioned here in that final testing does not always pick up this defect. Several occurrences of this type of failure have been experienced.

3. Vacuum availability from engine manifold is not always sufficient to pull back piston far enough. This results in lags at end of cycling.

4. Wear of piston "O" rings cause leakage of fluid in hydraulic system. Only one case has been found in the field to date in which this has occurred. The vehicle was used as a demonstrator model and experienced more use than would a normal vehicle. However, since transfer of ownership of older vehicles is common, service should outlast the vehicle or periodic maintenance must be prescribed.

To date, there is no record of actual life in terms of mileage for this characteristic.

Adaptors

1. Seizure of the steel drive shaft to the plastic housing of this component has occurred in the field. The cause for the seizure has been traced to the inability of the specified material to withstand the heat generated in the transmission of some vehicles. The central engineering staff has assigned a plastic specialist to work with our quality control and manufacturing engineers on this problem. Failure of this component can easily be detected, in that the speedometer indicator will not work. The unit will not function but normal braking power is not affected. This malfunction can result in excessive field service costs.

Viscosity Changes of Brake Fluid

1. Viscosity changes due to low temperatures may affect the functioning of the unit utilizing the metering valve. No tests have been conducted on this aspect to date.

IV. PROTOTYPING STATUS

1. Dual Unit

A. Vehicles prototyped.

1. 1965 Cadillac (all models except limousines).

2. 1964 Cadillac (hydra-matic transmission only).

B. Variable Kit Status.

1. Engineering

a. Operation sheets need revising.

2. Editorial

a. Templates - alterations required.

b. Instruction sheets - alterations required.

3. Availability of Components (all components available except:)

a. Templates.

b. Hydraulic tubing (1965 Cadillac only).

c. Instruction sheets.

C. Vehicles not prototyped.

1. 1966 Cadillac (all models).

2. 1965 Cadillac (limousines only).

*3. 1964 Cadillac (turbo-hydra-matic transmission only).

*4. 1963-1962 Cadillacs (all models).

5. 1966 Rambler (all models).

*6. 1965-1962 Ramblers (all models).

*The above mentioned automobiles were prototyped, but due to the addition of the transfer valve to the Perma-vac, each make and model will need changes in Variable Kit Components. Such changes in components as redesigning of templates, additional hydraulic tubing, additional vacuum hose,

and redesigning of the speedometer connection, require each make and model automobile to be reprototyped. One model of each of the above mentioned automobiles will require road testing to determine the necessity of a metering valve between the brake block and the Perma-vac.

2. Single Unit

A. Vehicles prototyped.

1. 1964 & 1965 Chevrolet (Impala, Biscayne, and Bel-Air models with V8 or 6 engine and automatic transmission only).

2. 1964 Buick (Wildcat - floor console, automatic transmission only).

3. 1965 Dodge (Polara, 880, and Monaco series, automatic transmission only).

B. Variable Kit status.

1. Engineering

a. Operation sheets need revising.

2. Editorial

a. Instruction sheets - alterations required.

3. Availability of Components (all components available except:)

a. Metering valve.

b. Hydraulic tubing.

c. Speedometer connection (1965 Polara only).

C. All G. M., Ford, and Chrysler automobiles except Oldsmobile 98 and 88 series, Chevrolet Corvette and Corvair, and 1965 Lincoln and Ford Thunderbird, were prototyped, but due to the addition of the transfer valve to the Perma-vac, and the necessity of a metering valve, each make and model will require changes in Variable Kit components. Such changes in components as redesigning of templates, additional hydraulic tubing, and vacuum hose, and changes in flexible cables, require each make and model automobile to be reprototyped and road tested. Due to front wheel speedometer drive

on Oldsmobile 98 and 88 series. anti-skid unit cannot be adapted to these cars at this time. Because of the higher wheel locking pressures required of disc brakes, the Chevrolet Corvette, 1965 Lincoln and 1965 Ford Thunderbird cannot be prototyped until further research and road testing is undertaken to determine if unit will function properly. In the near future, this problem will become more acute as disc brakes replace drum type brakes or become optional equipment on some automobiles.

DEFENDANT'S EXHIBIT 595

The Singer Company
Consumer Products Division
Elizabeth, New Jersey

Investment and Expenditures
Perma Anti-Skid Device

| | | |
|---|---|---|
| Physical Inventory (Valued at Direct Cost) | | $ 1,207,123 |
| Manufacturing and Testing Equipment | | |
| Gross Asset Value | $ 19,173 | |
| Less: Accumulated Depreciation | 1,824 | 17,349 |
| Monitor Contract Termination Cost | | 85,000 |
| Retrieval of Units from the Field | | |
| Actual Cost - 1965 | $ 117,989 | |
| Actual Cost - 1966 | 8,925 | |
| Estimated cost of Retrieving additional Units Installed by or Through Perma Research and Development Company | 50,000 | 176,914 |
| Royalty Prepayment | | 24,000 |
| Assumption of Perma Research and Development Company's Loan with Small Business Administration | | 82,320 |
| Payments Made to Perma Research and Development Company's Creditors | | 127,377 |
| Start up Manufacturing Expense in 1964 | | 47,368 |
| Operating Expenses in 1965 | | |
| Manufacturing Variances | $ 52,544 | |
| Inventory Adjustment | 18,211 | |
| Manufacturing Period Cost | 284,722 | |
| Allocation of Administrative Cost | 26,572 | 382,049 |
| Total | | $ 2,149,500 |

D-595

#595

DEFENDANT'S EXHIBIT 603

October 20, 1965

Mr. Burton C. Person
Director of Technical Services
The Singer Company
Consumer Products Division
30 Rockefeller Plaza
New York 20, New York

Dear Burt:

As per our conversation, please find attached, a listing of the High Aggregate Dollar Value Components which in total, represent approximately 90% of our present inventory value of Perma anti-skid components.

I am also attaching a diagram of the anti-skid control which indicates the location of the aforementioned components.

Very truly yours,

R. A. Kloby
Manufacturing Manager
Anti-Skid Control

RAK:ms

Att.

D-603



[DX 603, p 1]

October 20, 196

PERMA ANTI-SKID

HIGH DOLLAR INVENTORY ITEMS

| Part No. | Description | Amount |
|---|---|---|
| 17-342034 | Sensing Units | $ 698,000. |
| 17-342054 | Gear Box | 43,000. |
| 17-342033 | Perma-Vac Units | 31,000. |
| 17-342025 | Pressure Switch | 25,000. |
| 17-342531 | Contact Block | 25,000. |
| 17-342019 | Piston Spring | 23,000. |
| 17-342059 | Static Kits (Single) | 21,000. |
| 17-391001 | Hose | 18,000. |
| 17-342010 | Leather Packing (Diaphragm) | 17,000. |
| 17-342534 | Pressure Switch Plug | 15,000. |
| 17-342211 | Flexible Shafts | 14,000. |
| | Total | $ 930,000. |
| | Low Dollar Inventory Items | $ 240,000. |
| | Total Dollar Value of All Inventory | $1,170,000. |

603

DEFENDANT'S EXHIBIT 618

THE GINGER COMPANY
THIRTY ROCKEFELLER PLAZA • NEW YORK 20, NEW YORK

22

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21C

No. 1297

SEPTEMBER 1, 19 65

PAY TO THE ORDER OF MONITOR ENTERPRISES, INC. $ 05,000.00

FIVE THOUSAND AND NO/100 DOLLARS

FIRST NATIONAL CITY BANK
399 PARK AVENUE
NEW YORK, N. Y.

SEP 1 1965
NEW YORK

Authorized Signature

⑆0210⑈0008⑆ 02750729⑈ ⑈0008500000⑆

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PAY ANY U.S., F.R., OR TR. CO. P.E.R.

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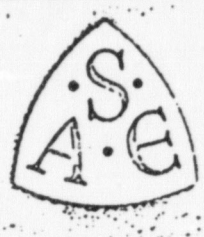
14. Page 8

[DX 653, cover]

OCT 19 1972

DEFENDANT'S EXHIBIT 653
(COVER, PAGE 7 "ADVANCED CONTROL CONCEPTS"
THROUGH PAGE 11 TO "ADAPTIVE STEERING"




# TECHNOLOGICAL DEVELOPMENT DIRECTING THE PATH TO FULLY AUTOMATIC VEHICLE CONTROL SYSTEMS

S.I. MacDuff
J.G. Rivard
E.J. McGlinn

The Bendix Corporation

SOCIETY OF AUTOMOTIVE ENGINEERS

International Automotive Engineering Congress
Detroit, Mich.
January 13-17, 1969

690260

ADVANCED CONTROL CONCEPTS (TOMORROW)

At the present time, several advanced control concepts are being developed by one or more of the research organizations of our industry. Each of these activities appears to be a clear and necessary evolutionary step in the direction of automatic vehicle control. These concepts are as follows:

1. Adaptive Braking
2. Adaptive Steering
3. Anti-Slip Traction Control
4. Advanced Auxiliary Power Sources
5. Collision Avoidance and Vehicle Spacing

ADAPTIVE BRAKING - In view of the fact that adaptive braking has recently been made optional equipment in one of our luxury cars, it was difficult to decide whether it should be classified as an advanced concept. However, since the level of continuing research activity in this area is so high, and the probability of substantial improvements are so great, it appeared desirable to consider this concept in the advanced category.

The introduction of automobiles with adaptive braking (anti-skid) systems is a great milestone in automotive history for two reasons.

1. It is the first time that vehicles are being equipped with a system having a sophisticated sensory capability, as well as a complex control logic implemented by a computer-like electronic circuit.
2. One of the first examples of the development of an automotive system by application of advanced systems engineering techniques.

An adaptive braking system has sensing and control elements which make it impossbile for the driver to operate the brake control to lock the wheels. In addition, this system will not allow the wheels to operate at a large percentage of slip. Ideally, it controls braking near the peak of the μ-slip curve. An adaptive braking system can produce stopping distances 10 to 15 percent less than locked-wheel stopping distances on a high coefficient road surface such as rough concrete, and can produce stopping distances as much as 50 percent less than locked wheel stopping distances on surfaces such as packed snow, which may have a coefficient of friction somewhere between 0.15 to 0.25.

Fig. 5 illustrates why this is possible. These curves show idealized characteristics of tractive effort of a tire on two different road surfaces under conditions of slip varying from 0 to 100 percent. The upper curve represents what might occur on dry pavement and the lower curve represents what might happen on a wet, slippery macadam surface. The increasing part of the two curves is referred to as the stable side. The shape of this part of the curve is probably largely determined by the elastic characteristics of the tire body and tread when stressed by traction in the plane of the wheel. The peaks of the curves are determined by the static friction coefficient of the tire and road surface, and the 100-percent slip value is determined by the sliding friction coefficient of the tire and road surface. Since the two curves represent the same tire on different roads, the forward part of the curve is shown to be the same until a peak is approached. The portion of the curves from the peak to the 100-percent slip

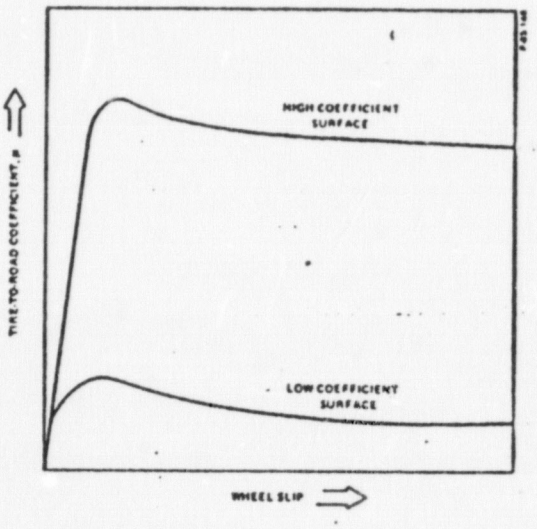



Fig. 5 - Tire μ-Slip Characteristic.

value represents combinations of static and dynamic friction coefficients resulting from the fact that as higher and higher slip develops, a greater part of the tire footprint is actually moving in relation to the road surface instead of clinging to it. The percentage of slip at which the peak of each curve appears is variable, being dependent on the slope of the stable part of the curve and the static coefficient of friction.

An early effort to develop adaptive braking consisted of sensing vehicle speed and wheel speed and then controlling the brakes to maintain a fixed percent of slip. However, the variation in location of the peak of the μ-slip curve with different tires prevented a fixed slip system from being completely optimum. In view of its simplicity, this system still might have been a satisfactory solution to the problem if it were not for the difficulty of sensing vehicle velocity while braking all four wheels. Determining vehicle velocity by measuring deceleration and integrating this value with time was considered. However, the effect of downhill slope upon this operation quickly discouraged this approach. Integration of the slope-caused acceleration error is cumulative and rapidly attains a value equal to the established slip percentage at a given vehicle speed. The control system, believing that slip is being maintained, progressively reduces the braking effort to zero.

The present approach is a classical one but the earlier attempts to solve the problems which this approach presented by old-fashioned cut-and-try methods of development did not produce a marketable system. Modern systems engineering technique is being applied now, and the results obtained to date seem to ensure ultimate success. It is probable that large-scale manufacture and application of adaptive braking systems to vehicles will occur within the next two or three years.

These systems will sense wheel deceleration and apply the fundamental logic that the vehicle cannot be decelerated in excess of 1g; therefore, a wheel which decelerates at an angular velocity greater than the equivalent of 1g vehicle deceleration is actually developing slip and approaching a locked-up condition. Earlier developers used overrunning flywheels as the decelerometers. They operated switches which controlled three-way solenoid valves to alternately connect the brake cylinders to a pressure supply and to a reservoir. Other earlier developers made these flywheels sufficiently massive to mechanically actuate the three-way valves to perform the pressure regulating function.

These empirically designed systems would limit cycle at the natural frequency of the system. The average braking pressure was usually much lower than the peak pressure that could have been utilized, and stopping distances were substantially greater than with locked wheels. Occasionally, the cycling frequency of the adaptive braking system matched the natural frequency of the vehicle suspension. The resulting resonant oscillations produced disturbing and occasionally destructive results. These systems were not easily adaptable to the passenger automobile because they demanded a continuous supply of hydraulic fluid under pressure. In fact, some systems required such large amounts of hydraulic fluid that supplying the demand was completely impractical.

The first practical anti-skid systems were successfully used in aircraft and in railroad trains because accomplishing a reduced stopping distance was not one of the primary objectives in adopting these systems. In both cases, the principal objective was prevention of damage to the running gear. With the automobile, however, it is considered essential that the elimination of tire slipping be accompanied by some decrease in stopping distance. The successful system which modern technology has evolved requires sensing when negative acceleration of the wheel exceeds the natural limit, lowering braking pressure at a controlled rate until the wheel acquires positive acceleration, permitting the wheel to accelerate until it approaches synchronous speed, and then applying increasing pressure at a controlled rate to re-establish the control cycle.

This system forces the wheel to oscillate back and forth across the peak of the μ-slip curve so that it is always operating very close to maximum braking effectiveness. The cyclic frequency is controlled within limits outside of the frequencies of vehicle suspensions.

Wheel velocity is sensed by a simple pulse generator, shown in Fig. 6 and 7, which produces current pulses at frequencies proportional to wheel velocity. This variable frequency is first converted into an analog of velocity and is then differentiated for acceleration. This is a very effective deceleration measuring system because of the low mass of the elements and the high signal strength which is obtained at low speeds.

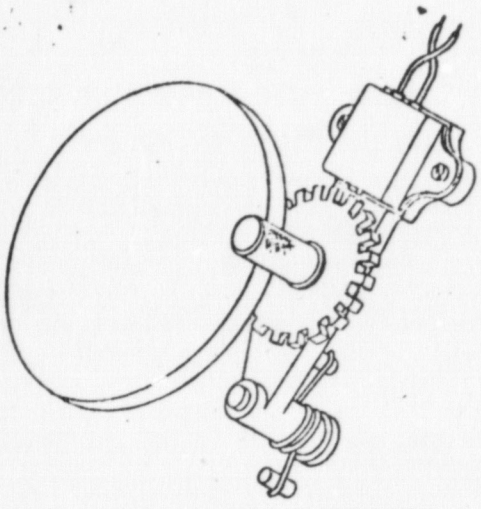


Fig. 6 - Wheel Velocity Pulse Generator.

Fig. 7 - Wheel Velocity Pulse Generator Installation.

When adaptive braking is applied to a vehicle having the conventional displacement hydraulic brake system, braking pressure is modulated by a vacuum-powered displacement modulator, as shown in Fig. 8. The modulator is controlled by solenoid valves which open and close in response to signals from the amplifier-computer.

Several anti-skid system configurations are shown in Fig. 9 through 19. By configurations we mean the number of wheels that are controlled and the means by which they are controlled. One configuration, shown in Fig. 9, is identified as C-1. Only the rear wheels are provided with sensors, and the wheel having the lowest velocity controls the application of braking pressure to both the rear wheels. This is called "select-low" operation. The C-1 configuration is a mini-

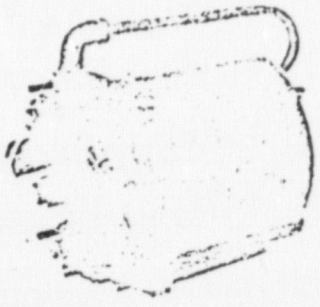


Fig. 8 - Vacuum-Powered Pressure Modulator.

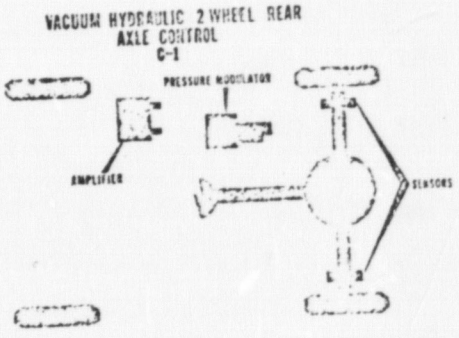



Fig. 9 - C-1 Rear Axle Control Adaptive Braking System.

mum system which provides directional stability while braking, but because it permits the front wheels to be locked, it does not maintain steering capability. Average performance of a C-1 system is shown in Fig. 10.

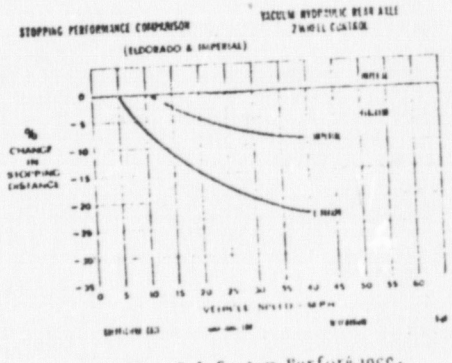



Fig. 10 - C-1 System Performance.

The configuration shown in Fig. 11 is identified as C-2. All four wheels are provided with sensors. The rear wheel sensors control the braking pressure to both rear wheels on a select-low basis. The front wheel sensors control the pressure to both front brakes on either a select-low or select-high basis. If a select-high basis is used, one of the front wheels may lock up. This system produces excellent stopping distances and directional stability, and a useful amount of steering control is retained.

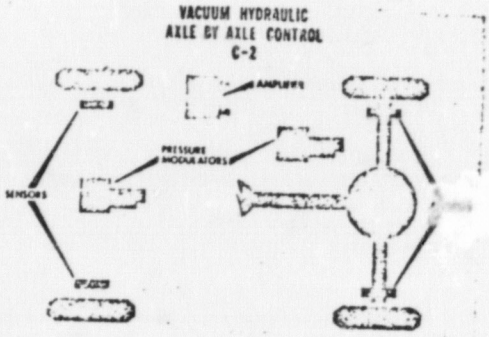



Fig. 11 - C-2 Two-Axle Control Adaptive Braking System.

The configuration shown in Fig. 12 is identified as C-3. All four wheels have sensors. There is one pressure modulator for the rear axle controlled by the rear wheel sensors on a select-low basis. There are two pressure modulators for the front wheels, each controlling one of the front wheels in accordance with its own sensor. This is nearly an optimum system, giving maximum improvement in stopping distances while maintaining directional stability and full steering control. Average performance of two vehicles equipped with C-3 configuration anti-skid systems is shown in Fig. 13.

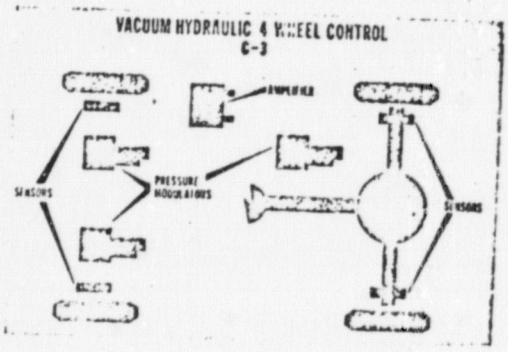



Fig. 12 - C-3 Rear Axle, Individual Front Wheel Adaptive Braking System.

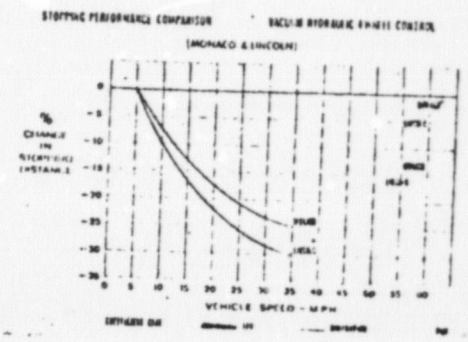



Fig. 13 - C-3 System Performance.

The configuration shown in Fig. 14 is identified as C-4. It shows promise of providing maximum benefits at minimum cost. Only the front wheels are provided with sensors which control a modulator (Fig. 15) that, in turn, varies the braking pressure to all four wheels. The pressure

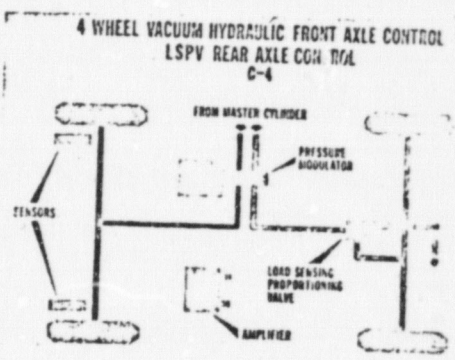



Fig. 14 - C-4 Single Modulator 4-Wheel Control Adaptive Braking System.

Fig. 15 - C-4 System Pressure Modulator.

directed to the rear wheels is further modulated by means of a load-sensing proportioning valve, shown in Fig. 16. This system may be sensitive to characteristic variations in brake performance. Fig. 17 shows the average performance of a vehicle provided with an adaptive braking system of C-4 configuration.

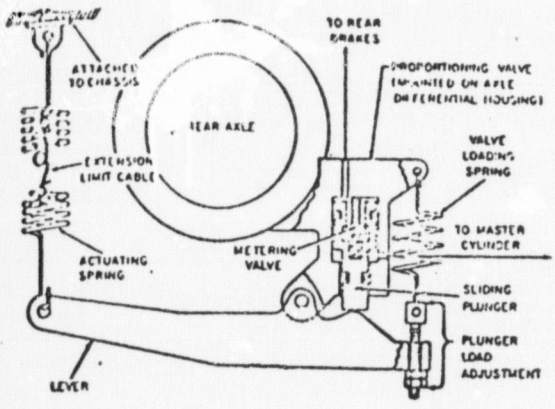



Fig. 16 - Load Sensing Proportioning Valve.

Fig. 18 shows a C-3 configuration which is completely hydraulically actuated. Initial braking energization is provided through a hydraulic booster powered by the output of the power steering pump. The three displacement pressure modulators are incorporated in a single housing and operated by fluid from the power steering pump which is stored under pressure by operation of an accumulator charging valve.

Fig. 19 shows a C-3 configuration in a vehicle utilizing a full power braking system in which an engine-driven pump provides pressurized fluid to an accumulator. Since this system offers a continuous flow of hydraulic fluid through the brake control valve, pressure modulation is provided by pairs of solenoid valves acting directly upon the pressurized fluid in the brake cylinders. One of these valves acts to interrupt the supply of pressure fluid to the brakes, and the other acts to release pressure fluid from the brakes. A typical adaptive braking amplifier (black box) is shown in Fig. 20.

DEFENDANT'S EXHIBIT 655

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
Two Pennsylvania Plaza, New York, N.Y. 10001

# The Chrysler "Sure-Brake" - The First Production Four-Wheel Anti-Skid System

J. W. Douglas
Chrysler Corporation

T. C. Schafer
Bendix Corporation

SOCIETY OF AUTOMOTIVE ENGINEERS

Automotive Engineering Congress
Detroit, Mich.
January 11-15, 1971

710248

710248

# The Chrysler "Sure-Brake" - The First Production Four-Wheel Anti-Skid System

T. C. Schafer
Bendix Corporation

J. W. Douglas
Chrysler Corporation

In 1966 Chrysler became very interested in testing and developing production designs of skid control brake systems. Research work had been in process since 1957 but not on production designs. Now various suppliers were moving forward in developing such devices and it was obvious that it was just a matter of time before a system was sufficiently advanced to warrant development on a specific system with the objective of installation on a volume production vehicle. The potential benefits obtained by such devices were well known, the most important being directional stability and control during braking. It was recognized that a rear wheel system would keep the vehicle travelling in a straight line but it would have no steering capabilities. A four-wheel system, although having considerable complexity, would have the tremendous advantage of retaining steering control. A further potential advantage lay in obtaining shorter stopping distances on many surfaces where rolling friction was higher than sliding friction.

Knowing the potential was one thing; how to utilize it was another. Some of the alternatives to be considered were:

1. Four-wheel or rear wheel only?
2. Mechanical inertia or electronic sensors?
3. Sense the rear wheel accelerations at the wheels or at the drive shaft. If sensed at the drive shaft, which end would be best - the speedometer cable pick-up or at the differential housing?
4. Should the modulator power source be vacuum, hydraulic, electric, or compressed air?
5. If vacuum power was used, could the inevitable large pressure reducers or modulators be packaged?
6. Could a single combination power brake booster and modulator be developed to provide satisfactory performance at an obviously lower cost.

Many of these questions were resolved by testing various suppliers' systems at the Chrysler Proving Grounds. It was finally decided that the system would be vacuum powered with an electronic logic controller and have an electromagnetic sensor at each wheel. Initially, no decision was made whether to develop a rear-wheel or four-wheel system and so parallel programs were carried out for several months.

As experience was gained, it was concluded that to provide a truly advanced braking system, a four-wheel system was needed. The rear-wheel-only device, while generally keeping the vehicle travelling straight, had several deficiencies.

1. There was absolutely no steering control with the front wheels locked; no matter which way the driver steered, the vehicle would continue to travel straight.
2. The vehicle on a crowned or cambered road or under heavy crosswind conditions would tend to drift sideways, especially on a low friction surface, where it could collide with a parked vehicle.
3. Front tires could be easily damaged on higher coefficient surfaces since they would lock under "panic type" braking situations.
4. Stopping distance was generally longer than that obtained by use of a four-wheel system.

ABSTRACT

The paper outlines testing, development and operation of the first production four-wheel slip control system for passenger cars in the United States. The Chrysler Corporation calls the system "SURE-BRAKE", but it is more generally known as "anti-skid."

The first portion of the paper deals with considerations that led Chrysler into the "SURE-BRAKE" system, the philosophy behind the system and a detailed explanation of its operation. The second portion deals with the development and testing leading to the release as an option on the 1971 Imperial.

The testing program introduced a new dimension to brake engineering. Before the advent of wheel slip control systems, many thousands of brake tests were conducted but were always terminated at the point of skid. These tests were also conducted mainly on black top or concrete roads. For the first time, thousands of stops were made at maximum deceleration on every available surface. The paper lists the results obtained and attempts to pass on some of the lessons learned in handling skidding vehicles.



[DX 655, p 2]

5. Under split coefficient conditions the vehicle would drift to the higher coefficient side and corrective action was impossible.

Having examined the problem, it was then possible to formulate a few ground rules. These were:

1. The vehicle must have good steering control and stability under all braking conditions.
2. Stopping distances must be less than that obtained by a skilled driver stopping in the minimum distance without skidding his tires.
3. The braking system must be unaffected by the weight distribution of the vehicle.
4. The system must be capable of installation on the normal production line as a vehicle option.
5. The system must be in production for the 1971 Imperial.

Given the preceding ground rules, it was evident that:

1. It had to be a four-wheel system.
2. The sensing system could be either at each individual wheel, or at each front wheel and one rear axle. It was finally decided to install one sensor per wheel.
3. The simplest system that could be developed in time had to be vacuum powered. Hydraulic power was definitely a possibility, but not at this stage.

The Bendix system offered the greatest potential of attaining these objectives. A joint test and development program was then instituted with The Bendix Corporation to reach the production date with an effective, thoroughly tested durable system.

To better understand how these requirements are met, it seems appropriate to discuss the basic tire-to-road relationship. These characteristics are depicted by the Mu slip curve.

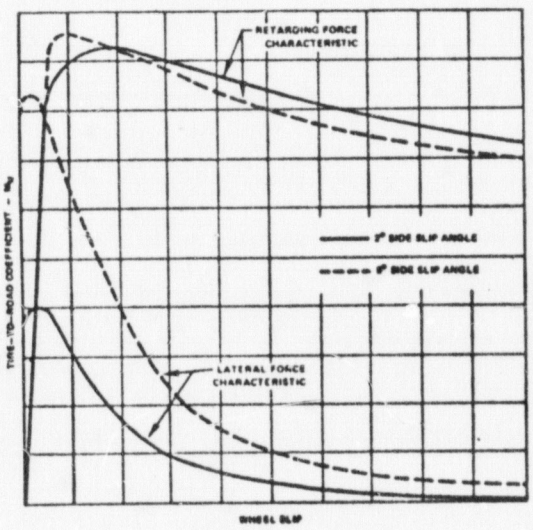



Fig. 1 – Typical Tire–To–Road coefficient vs. wheel slip characteristics

Figure 1 shows a typical plot of the retarding force characteristic and the lateral force characteristic.

The retarding force of the tire generally exhibits a rather sharp rise as wheel slip increases, peaking at some point, and then falling off as the wheel approaches a locked condition. This does not change appreciably with side slip angle, at least in the region most commonly encountered. Typically, then, the "SURE-BRAKE" system controls braking so as to stay at or near this peak, resulting in maximum retarding force and, thereby, reduced stopping distance. The lateral force characteristic varies considerably with both wheel slip and side slip angle. It also peaks as wheel slip increases, but at a lesser value than the retarding force and then diminishes rapidly as wheel slip increases, as shown on Figure 1. Since maximum retarding force and maximum lateral force cannot exist simultaneously the "SURE-BRAKE" system operates in such a manner as to provide maximum lateral force consistent with maximum retarding force. The lateral force characteristic provides vehicle stability in the case of the rear wheels and vehicle steerability in the case of the front wheels.

Figure 2 is intended to clarify the action of the wheel as it is cycled back and forth about the peak. The upper line, $V_V$, represents vehicle speed and the two lower lines $S_1$ and $S_2$ represent the limit of wheel speed as it cycles about the peak retarding force. $V_W$ shows the wheel oscillation between these limits.

Stability refers to the resistance to sideways movement or spinning of the vehicle, such as that which occurs when the rear wheels lock on a side-to-side unbalanced coefficient or in a curve. Controllability, to differentiate from stability, is primarily a front wheel function and refers to the ability to steer the vehicle under maximum braking conditions.

In order to achieve the previously mentioned objectives, the "SURE-BRAKE" system controls each front wheel individually and the rear wheels as a pair. This results in three control channels each consisting of a pressure modulator, electronic control circuit and a speed sensor. Figure 3 shows

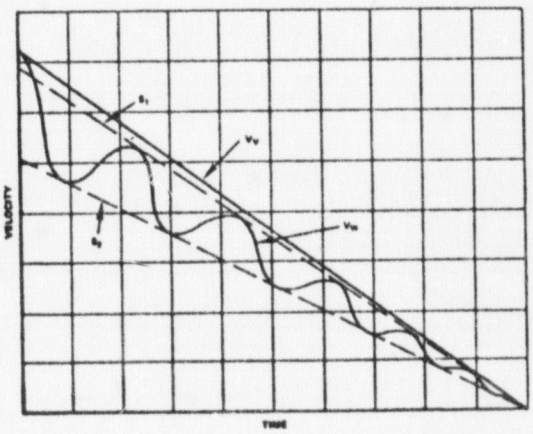



Fig. 2 – Interrelationship between wheel and vehicle velocities

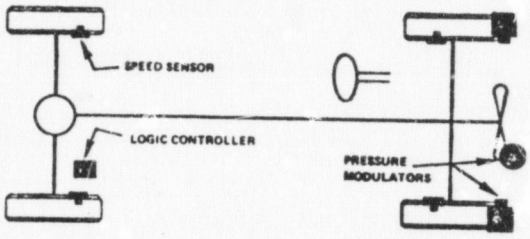



Fig. 3 – "SURE–BRAKE" component configuration

the hardware arrangement. In the case of the rear wheels, it is necessary to select which wheel will control that channel. A "select low" approach proved to be the most desirable scheme for good overall performance. This means that the rear wheel approaching the locked wheel condition first controls the operation of the rear channel.

Each of the three "SURE-BRAKE" channels sense the appropriate wheel speed and use this intelligence as the input signal to the logic controller. The logic controller contains the program by which the system operates. When it determines wheel lock is imminent, signals are sent to the control valves on the appropriate modulator. The pressure modulator provides the muscle to adjust brake pressure so as to keep the wheel at or near peak retarding force.

The three channels of the "SURE-BRAKE" system operate independent of each other. The only inter-connection is with respect to failsafe. The failsafe system is designed to negate function in all three channels if a "SURE-BRAKE" failure is detected in any one channel. When failure is detected, the brake failure light is illuminated and latched "on" until the ignition is de-energized. As discussed earlier, only those failures that produce reduced braking over that achievable with a standard brake system are detected and indicated.

## "SURE BRAKE" COMPONENTS

SPEED SENSOR – The speed sensors are electro-magnetic devices which continuously monitor each wheel speed. Due to design variances and deflection differences between the front and rear brakes, two sensor designs were implemented.

The front sensors shown in Figure 4 are a "frictionless" type design in that there are no wearing surfaces. The sensor, consisting of a magnet, coil and toothed pole piece, is encased and mounted to the stationary knuckle. The sensor is opposed by the tone wheel which is a large toothed wheel fixed to the rotating disc and hub assembly of the front brake. All teeth in the tone wheel are encapsulated to prevent foreign objects from lodging in the voids and causing possible damage. The gap between the sensor and tone wheel is adjustable and set at .020". This arrangement yields a minimum output of 0.5 volts peak-to-peak at 5 MPH and increases in voltage output as speed increases. The sensor output frequency is approximately 42 Hz./MPH, which provides sufficient flow of information to obtain good system control.

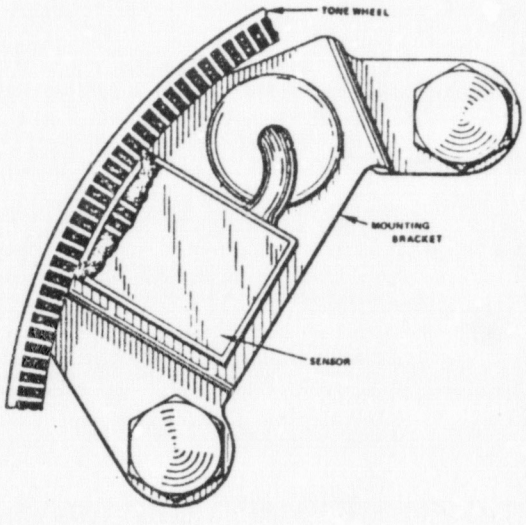



Fig. 4 – Frictionless speed sensor

In the case of the rear sensors, sizable deflections can occur between the rotating and non-rotating members of the rear brake and axle assembly. These large deflections made it impractical to use the "frictionless" approach. Therefore, a "friction drive" design was implemented as shown in Figure 5. The rear sensor provides the same voltage and frequency characteristics as the front sensor. The rear sensor and tone wheel are mounted on a spring loaded bracket, with a fixed air gap between the sensor and tone wheel. The tone wheel when assembled on the vehicle rides on the inside dia-

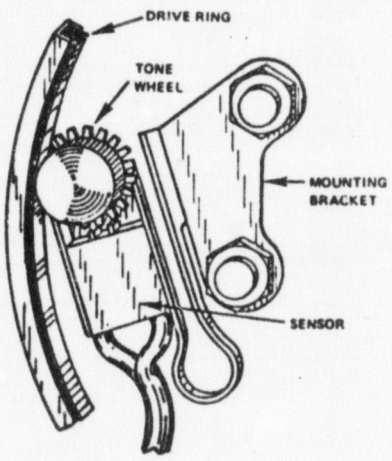



Fig. 5 – Friction drive speed sensor

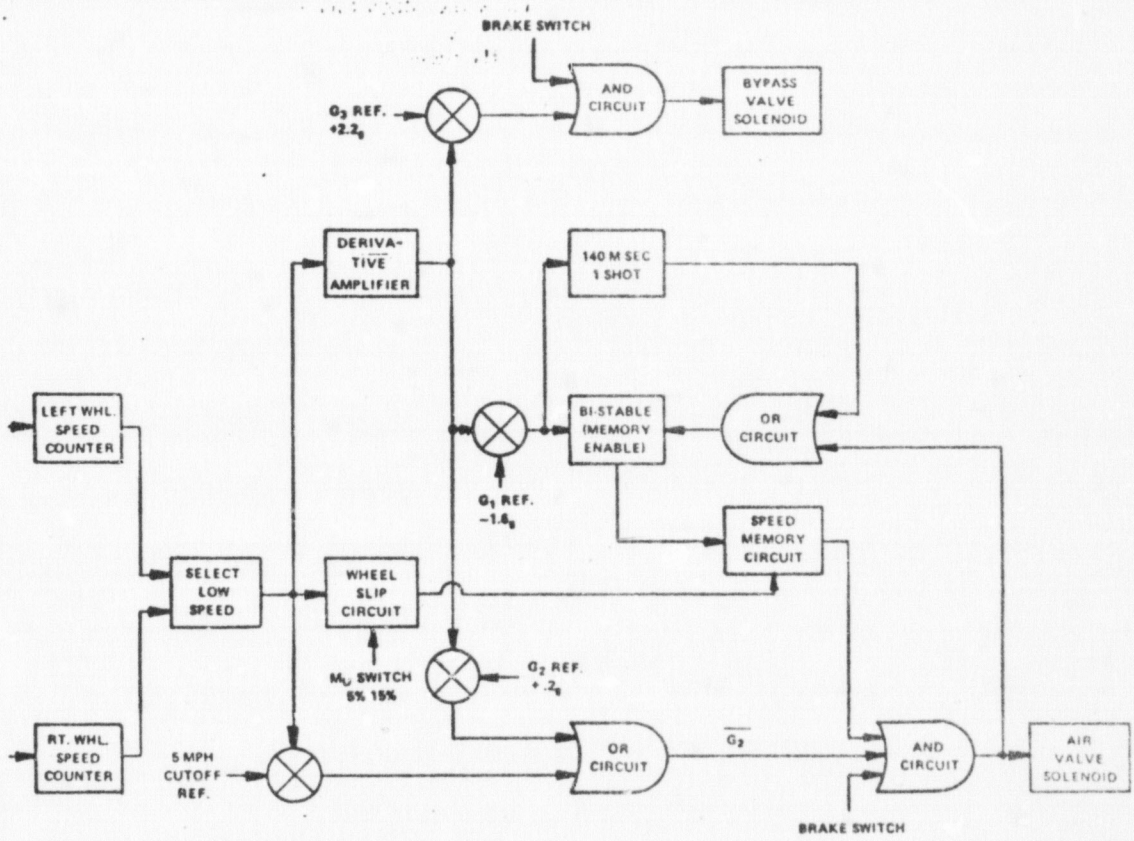



Fig. 6 – Logic controller – functional block diagram

meter of the rubber drive ring and can easily absorb run-out variances of 0.100".

The drive ring, being attached to the axle flange, rotates as the vehicle wheel turns, resulting in a corresponding rotation of the tone wheel. The tone wheel has a light knurl on the outside diameter to provide positive engagement between the tone wheel and drive ring.

## LOGIC CONTROLLER

The logic controller is the "computing module" or "brains" of the "SURE-BRAKE" system. It receives input signals from the speed sensors, processes these signals and issues commands to the pressure modulator control valves when wheel lock-up is imminent. Figure 6 is a functional block diagram for the logic controller and Figure 7 shows the interrelationship between wheel speed, wheel acceleration and brake pressure and is included to further clarify system operation. Referring to these two figures, the operation of the logic controller will now be explained. The functional diagram shows the "select low" logic, referred to earlier, which applies to the rear axle operation only. The front wheel operation utilizes identical logic, except the wheel speed selection circuitry is not necessary.

Wheel speed enters the logic controller where it is processed and differentiated electronically. When the wheel deceleration signal reaches 1.6 "G", the system memorizes wheel speed. This memory is maintained for approximately 140 milli-seconds. If during this time interval the wheel speed falls a predetermined amount below this memorized value when the brake is applied, the command is issued to decay or reduce brake pressure. If not, the memorized speed signal is cancelled. The percentage change in speed from the memorized value required to decay pressure is either 5% or 15%, depending on vehicle deceleration. Below approximately 16 ft/sec/sec vehicle deceleration, the 5% value exists; above 16 ft/sec/sec it is 15%. This adaptive feature was found necessary to obtain good performance under all tire-to-road conditions.

As brake pressure is reduced, the wheel ceases to decelerate

ate and starts to accelerate. When it reaches a slightly positive acceleration value, such as, 0.2 "G", pressure decay is discontinued and a low pressure build rate initiated. If the wheel acceleration exceeds a value of 2.2 "G", the system builds pressure at a more rapid rate. This fast build rate continues until the wheel acceleration falls below the 2.2 "G" level at which time the system reverts to the low pressure build rate until the wheel reaches incipient lock, when the cycle repeats.

The system incorporates a low speed cutout below 5 mph. This function is required since sensor output becomes unusable at low speeds.

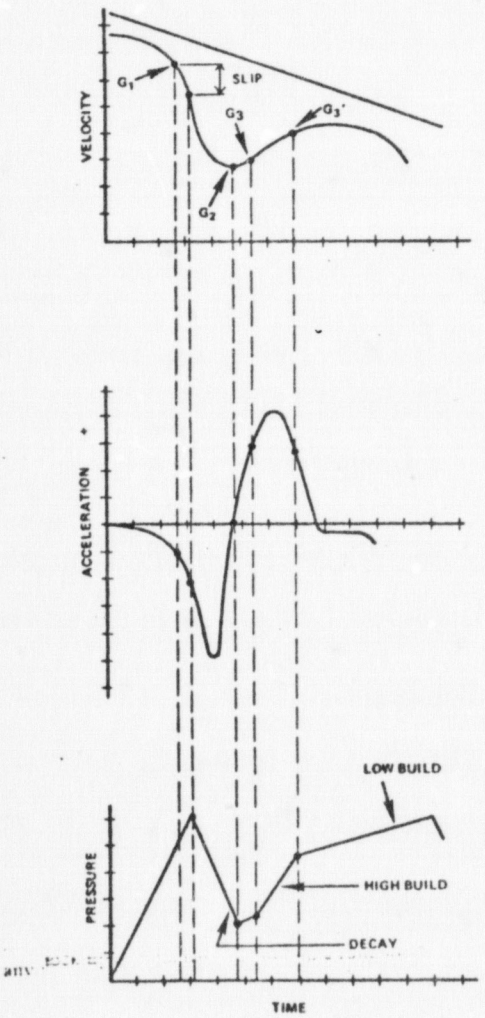



Fig. 7 -- Interrelationship between wheel velocity, acceleration and brake pressure

## PRESSURE MODULATOR

The pressure modulator provides the muscle to cycle brake pressure upon receipt of signals from the logic controller. Figure 8 is a schematic diagram of the pressure modulator. In the normal de-energized position, the hydraulic check valve is held open by the displacement plunger, allowing brake fluid to pass freely from the master cylinder to the wheel cylinders. This plunger is spring loaded to withstand a minimum pressure of 1450 PSI before retracting due to fluid pressure alone. During operation of the vehicle, the modulator is evacuated by use of engine vacuum. A vacuum check valve is incorporated in the vacuum inlet line to the modulator for the purpose of maintaining a high vacuum level in the modulator and to prevent gasoline fumes from entering the modulator on engine shut down or during acceleration.

During "SURE-BRAKE" operation, the pressure modulator reduces and increases brake pressure through operation of the solenoid control valves. As brake pressure increases sufficiently to cause incipient wheel lock, the control system energizes both control valves. This causes the normally closed air valve to open and the normally open bypass valve to close. In this condition, atmospheric pressure is admitted to the front side of the diaphragm creating a differential pressure. As this differential pressure increases, it overcomes the spring preload and retracts the pneumatic portion of the modulator. As the displacement plunger follows, the hydraulic check valve closes terminating communication between the master cylinder and the wheel cylinder. Continued movement of the displacement plunger creates additional volume in the wheel cylinder side of the brake system causing brake pressure to decrease. As can be seen in the diagram, the displacement plunger is not fixed to the pneumatic piston, thus preventing the possibility of developing a negative pressure in the brake line which could admit air into the brake system through the wheel cylinder seals.

After the brake pressure has been reduced sufficiently to allow the wheel to accelerate, the "SURE-BRAKE" system reverts to either "low build" or "high build", depending on the magnitude of wheel acceleration. High build is accomplished by de-energizing both valves preventing the entrance of air through the air valve and opening a relatively large orifice between the front and back side of the pneumatic piston by use of the bypass valve. This causes rapid equalization of pressure across the diaphragm, resulting in rapid advancement of both the pneumatic and hydraulic pistons due to the modulator spring, thereby, increasing brake pressure at a rapid rate. If the wheel acceleration is low, the air valve is de-energized and the bypass valve is kept energized. A small bleed in the bypass valve short circuits the main orifice allowing the differential pressure across the diaphragm to diminish at a slow rate. The resulting action builds brake pressure slowly.

The electrical switch on the modulator is part of the fail-safe function. This switch is normally open when the modulator is in the de-energized position. When closed in the absence of a brake light signal, this indicates that the modulator has erroneously retracted. This switch signal results in deacti-

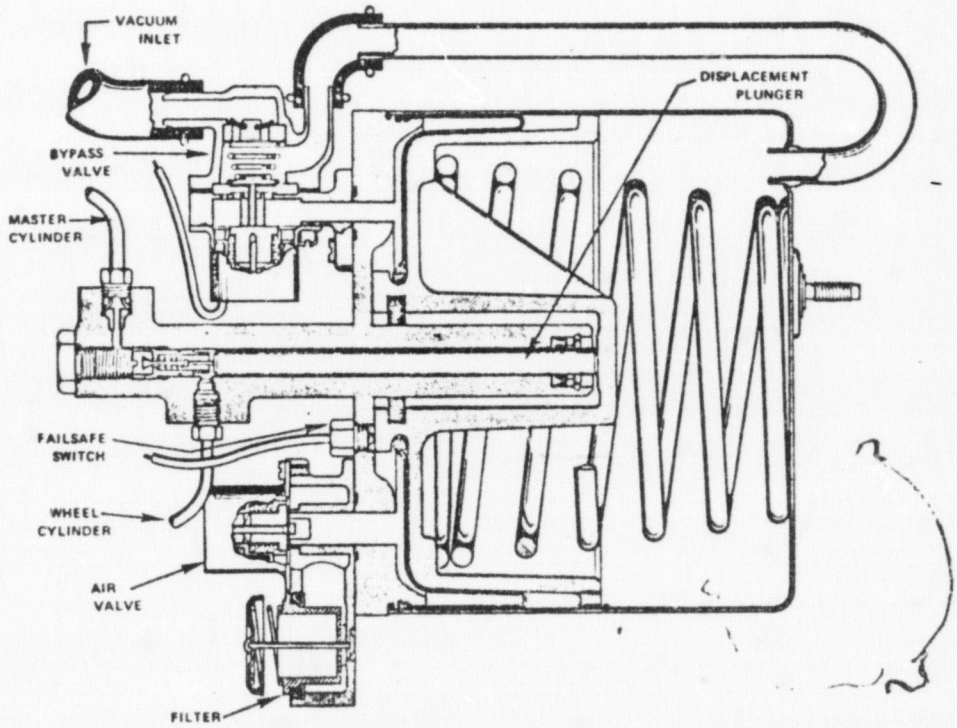



Fig. 8 – Pressure modulator

vation of the system electronically and the subsequent illumination of the brake failure light.

To insure that the modulator receives frequent exercising to keep the interface between the displacement plunger and the seal lubricated, the system incorporates a "power on transient". This function energizes the modulators for approximately 20 milliseconds every time the engine is started with the brakes applied. This time interval is adequate to fulfill the intended exercise function with negligible vehicle motion on steep grades.

To prove out the "SURE-BRAKE" system, extensive testing was conducted. The following sections review this test activity and some of the associated problems.

## VEHICLE TESTING

Testing soon showed that the American passenger car is indeed a very forgiving vehicle and will not turn over under any provocation, providing it remains on a hard flat surface. Thousands of skid stops up to 80 MPH have been made without tipping a car over although vehicles have often spun through as much as 390°.

One of the most useful development tools in the early stages was a split coefficient of friction surface consisting of a sheet of wetted stainless steel adjacent to a dry concrete road. This simulates conditions such as driving with two wheels on a gravel shoulder or on a patch of ice while the other wheels are on a high friction surface. On hitting the brakes hard, the difference in tire drag produces a torque on the vehicle pulling it towards the high friction surface such that the vehicle turns crossways on the road. This action is extremely rapid and one the normal driver cannot correct for with a conventional vehicle.

With "SURE-BRAKE" the vehicle experiences a pull towards the high friction surface, but this pull can be easily corrected and the vehicle can be steered readily in any direction.

Steering control is one good measure of the usefulness of a wheel slip control system but it is not always enough to steer out of an accident. The vehicle must stop too and so stopping distance tests are conducted on the various surfaces at the Chrysler Proving Grounds at different speeds. We compared stopping distances under three conditions:

1. Locked wheel
2. "SURE-BRAKE" control
3. Skilled driver, minimum stopping distance without locking wheels.

Figure 9 gives the average values obtained from approximately 1,000 stops. From the table, it can be seen that in all cases

where we have comparative figures, the "SURE-BRAKE" control system provides shorter stopping distances than obtainable by the skilled driver.

The skilled driver results reported in this paper were obtained by "seat of the pants" evaluation with no decelerometer or pressure gauge aids.

Initially stopping distance was measured by means of a gun firing a chalk pellet onto the pavement upon applying the brake pedal. The stopping distance was then measured by a tape measure and the distance recorded. This method was time consuming, requiring two men, and with the advent of cold or wet weather a very unpleasant job. The Chrysler Corporation Instrument Laboratory built fifth wheels with a Nul speed indicator to provide accurate preset initial test speed readings. A four digit electronic counter with a "NIXIE" tube display is used for reading the stopping distance from the instant of the initial movement of the brake pedal to rest. This enabled the test to be conducted with one driver who could record the results without leaving the car. A further modification made by Brake Engineering was to build an air cylinder device which lifted the wheel clear off the ground should the vehicle rotate more than $60^{0}$ while skidding. This innovation has saved many very expensive fifth wheels.

The biggest problem was the wide variation obtained in stopping distance results. To reduce this effect to a minimum, it is necessary to run 10 stops with and 10 stops without "SURE-BRAKE" control, using the average to determine the reduction in stopping distance. This variation exists equally with locked wheels and "SURE-BRAKE" control stops and appears to be due to driver variation in reading the vehicle speed indicator, the driver brake application rates, and the response in the power brake booster.

To facilitate gathering of data, the distance of each stop is recorded on a punched card along with other information such as vehicle weight, tire size, material, tire manufacturer, ambient temperature, surface and speed. This information is used to compute average stopping distance and for determining subtle changes caused by revisions to various components.

During the course of this work, a certain amount of knowledge has been acquired in making hundreds of locked wheel stops from speeds of 60 and 80 MPH without accidents or problems. Accordingly the following simple rules have evolved.

1. Seat belts to be used at all times and properly tightened.
2. Doors locked.
3. Once the brake has been applied, it must be fully on until the vehicle comes to rest.

Number 1 and 2 are normal precautions all drivers should take. Number 3 is not so obvious and is yet the most important. Newton's first law of motion states that every body continues in its state of uniform motion in a straight line except in so far as it may be compelled to change that state by the action of some outside force.

If a vehicle has all four wheels locked, it may start to spin due to differences in tire-road friction values across the road width. It will still continue to travel along the highway virtually in a straight line and finally halt, usually on the highway and rarely more than a few feet over the shoulder. The vehicle tends to drift down the road camber but should it not halt before actually running onto a gravel shoulder, the higher friction value of the highway will tend to pull it back onto the road. As long as the vehicle stops on the flat road, it cannot roll over.

If one examines many accidents in which vehicles have halted many yards from the highway or have crossed into oncoming lanes, it is apparent that in many cases the driver lock-

| Speed | Surface Condition | Locked Wheels | "SURE-BRAKE" | Skilled Driver |
|---|---|---|---|---|
| 30 | Dry Concrete | 42.2 Ft. | 43.3 Ft. | 56.2 Ft. |
| 60 | | 159.2 | 165.3 | 192.5 |
| 80 | | 306.9 | 306.1 | 345.1 |
| 30 | Wet Concrete | 42.7 | 43.1 | 56.2 |
| 60 | | 199.8 | 176.5 | 215.2 |
| 80 | | 442.7 | 347.6 | 427.5 |
| 30 | Gravel | 52.4 57% | 64.5 | 76.3 |
| 60 | | 200.6 | 265.0 | 289.7 |
| 45 | Wet Jennite | 314.7 71% | 185.5 | 263.7 |
| 45 | Washboard Road | 93.0 | 77.4 | 110.3 |
| 45 | Snow and Ice | 255.2 | 226.9 | 260.5 |
| 60 | | 424.5 28½% | 417.3 | 521.0 |

Fig. 9 – Average Stopping Distance

ed up the brakes. Then, upon starting to spin the driver released the brakes. The effect of releasing the brakes causes the vehicle to charge off in the direction it is pointed, provided the vehicle has not turned beyond steering limits. Under such conditions high inertia forces are placed upon the driver which can move him from the vehicle controls unless he is suitably restrained.

As mentioned before, with front wheels locked and rear wheels revolving, the vehicle will skid in a straight ahead position. Should the rear wheels lock with the front wheels still revolving, the vehicle is virtually uncontrollable and requires a high degree of skill to keep it within a traffic lane. Frequently a steering maneuver with this condition, especially on wet surfaces, is almost certain to spin the vehicle around.

STOPPING DISTANCE TEST SURFACES

In order to develop the "SURE-BRAKE" system hundreds of stops were made by many test cars on a wide variety of surfaces.

DRY CONCRETE – A vehicle can stop in a comparatively short distance with a maximum of noise and smoke with the wheels locked on dry concrete. Six locked wheel stops from 80 MPH are usually sufficient to wear holes through new tires. "SURE-BRAKE" stops can be run continusouly without flat spotting the tires and the vehicle is always under steering control. The vehicle without wheel slip control may spin and halt facing the direction from which it came. The condition of the tire tread is unimportant. Worn smooth tires provide as short a stopping distance as new treads.

WET CONCRETE – The condition of the tread is most important. The stopping distances listed relate to new or partially worn tires. Bald tires would have greatly increased the stopping distance because of lack of drainage allowing a wedge of water to form. However, the comparison between locked wheel, "SURE-BRAKE" and skilled driver would have been unchanged. The "SURE-BRAKE" stop would still be shortest.

WASHBOARD BUMPS – Initially, very low rates of deceleration were obtained on washboard bumps. These bumps are normally encountered on gravel roads but at the Chrysler Proving Grounds a chatter bump stretch made of asphalt on the vehicle endurance road was used and provided a constant test surface.

The wheel or wheels bouncing upwards tended to lose traction with the road and due to brake torque would tend to lock. The sensors send this intelligence to the logic controller which in turn reduced pressure to that wheel or axle, thus lowering the deceleration of the vehicle to a very low level. This problem was resolved by modifying the circuitry in the logic controller. To prove that the changes in the logic controller had corrected the problem it was necessary to make hundreds of stops at maximum deceleration over the washboard surface road. The vehicles were stopped from speeds of 20 MPH to 60 MPH at 5 MPH increments, twenty stops at each speed were made. It says much for the toughness of the vehicles that they were able to withstand such poundings.

JENNITE SEALED ROAD – Jennite is an asphalt sealer and has the characteristic of producing a very low sliding coefficient of friction when wet and a high rolling coefficient of friction. This test surface represents conditions encountered in the summer on some asphalt roads when the surface becomes polished and oily during periods of dry weather, then the first downpour of rain produces a low friction surface until the rain has washed off the slick film. The stopping distance of the car with "SURE-BRAKE" control is reduced by almost half compared with the locked wheel condition. This surface is one of the few in which a skilled driver pumping the brakes can indeed beat the stopping distance of the locked wheel car.

GRAVEL ROADS – It was found that the shortest stopping distance was obtained by hitting the brake hard, locking up all four wheels and plowing a deep groove in the road. During such a stop, there is, of course, no steering control but stopping distance is short.

There appears to be no way that a rolling wheel on top of gravel can produce as much resistance as one in a snowplowing situation. The vast majority of customers, however, could be better served with a system assuring steering control at all times on gravel and still providing decelerations greater than obtained without skidding wheels.

SNOW AND ICE COVERED ROADS – The table (Figure 9) lists average stopping distances and gives a good relative data between locked wheel stops and "SURE-BRAKE" stopping distance results but the numbers themselves depend too much on variables such as depth of snow and temperature. In a group of 113 locked wheel stops, it was found that the stopping distance from 30 MPH to rest varied from 82 feet to 213 feet. It is certain that more tests would provide even wider results.

SPLIT COEFFICIENT OF FRICTION SURFACE – This facility readily duplicates two common situations. In the winter, it is not unusual to find patches of ice or snow on an otherwise bare dry road. Also many highways have gravel shoulders. Should a vehicle straddle such surfaces with two wheels on one side on a low friction surface and the two others on the high friction surface, a locked wheel stop will immediately rotate the car sometimes through 180°. For such a test, it is important that the brake not be released until the vehicle has halted; otherwise, the vehicle will charge off in the general direction it happens to be pointed. To reproduce this split coefficient of friction surface, a 80 foot long x 3 feet wide sheet of stainless steel was laid down adjacent to a concrete road. With the stainless steel stip wetted, the friction values correspond closely to a sheet of ice.

With this facility, the effectiveness of the wheel slip control system was determined. Tests showed that a vehicle without a wheel slip control system will spin out. Further tests revealed that a rear wheel only system will stop virtually in a straight line with two or three feet deviation. A four wheel slip control system is capable of steering straight ahead or indeed in any direction including lane changing.

Since a vehicle without an effective wheel slip control system will spin out as soon as sufficient hydraulic pressure

has been delivered to the brakes, this split coefficient test proved to be an excellent screening tool for various systems offered.

## SYSTEM PROBLEMS

The majority of system problems stemmed from salt and water causing a leak path from the 12 volts system to the millivolt circuits of the wheel control system. The solution was to isolate high voltage connections from low voltage ones and, where possible, install all connections in dry areas.

To resolve the problems, we used an eight channel light beam oscillograph to record the events occurring throughout the stop. The various readings taken during test stops were:

Master cylinder pressure.
Brake pressure.
Sensor output from each wheel, being proportionate to speed; this showed the action of each wheel.
Modulator air valve and bypass valve actuation.
Internal signals from the logic controller giving the acceleration of each wheel.

By examining these various signals, or absence of such signals, it was possible to identify the problem and by making various changes, eliminate the trouble.

In addition, to keep it dry, the logic controller was moved from behind the right headlamp to the trunk. As always, this solution, while removing most of the problems, introduced several new ones. The sensor leads now having to run to the rear were adjacent to 12 volt power supply lead and began to pick up induced currents which, in turn, were relayed to the logic controller as erroneous signals. This caused the system to fire unnecessarily. This problem was finally solved by shielding the sensor wires. By this time the system was quite reliable but on occasions a wheel would skid for no apparent reason. The drivers on the night shift were also finding this problem but much more frequently. Due to its random malfunctioning, the problem was difficult to isolate and resolve. Finally, it was discovered that the problem was accentuated by the radio. The night shift drivers had the radio on while the engineers trying to discover the failure turned it off to give their full attention to the problem. This particular problem was finally traced to the electronic voltage regulator which was feeding in "hash" to the electrical system which in turn caused the air valve to shut off prematurely and allowed the wheel to go to skid. A change was made to the electronic circuit which corrected this problem by filtering out these random spikes.

The other parts of the system were comparatively trouble free, although some speed sensor failures were caused earlier by leaking bearing seals. This problem was corrected by improved sealing design.

The modulators which do the actual work of reducing or modulating the pressure have proved to be trouble free whether on test cars cycled frequently or on endurance cars and cycled rarely. Some corrosion was encountered on air valve springs and piston but a change to stainless steel for these parts corrected that problem.

## STARTING ON STEEP GRADES

To ensure that the modulators do not deteriorate through years of inactivity, the modulators are cycled each time the vehicle is started with the brake pedal depressed. During a normal start cycle there is no problem; the duration of the cycle is so short with normal brake pressures nothing happens. However, if one turned off the engine and applied the brake pedal several times to exhaust the power brake booster, considerable brake pedal pressure is required to generate 350–400 PSI, the pressure required to just hold the vehicle on the 32% grade. Under these circumstances on restarting the vehicle the modulators cycled in the normal manner and the reduction in hydraulic pressure permitted the vehicle to roll downhill under the force of gravity until the engine started restoring the power brake booster to full effectiveness. The problem was corrected by logic controller circuit changes, thus cutting down the rollback to a maximum of eight inches. In comparison, a manual transmission car on stalling rolled nineteen inches before the driver could stop it. It must be emphasized that with the parking brake applied or with normal vacuum levels in the power brake booster, no rollback of the vehicle takes place.

In addition to the normal Brake Engineering development program at the Chrysler Proving Grounds, endurance testing was carried out by other departments. The normal cycle consisted of driving for 50,000 miles over a wide variety of roads from concrete and asphalt to gravel, including washboard bumps, widely spaced bumps, smooth concrete, brine saturated gravel, loose stones and a periodic pass through the splash trough. Speeds varied from 40 MPH while traversing bumps to 100 MPH around the high speed oval. At the end of the 50,000 mile cycle, the vehicles were stripped down and all components carefully examined for wear or damage.

## TEMPERATURE TESTING

Most endurance work was done at the Chrysler Michigan Proving Grounds but for the past three years vehicles have been running at the Chrysler Phoenix Test Station, Arizona, where ambient summer temperatures frequently reach 110°F.

In order to obtain test data at various temperatures and altitudes, road trips were conducted both by Bendix and Chrysler Corporation. In the middle of winter, trips have been made up north to Stephens Point, Wisconsin, and Bemidji, Minnesota, where tests were conducted on the airport runway which had been wetted down to form ice. During the summer months, road trips were made to Death Valley, Nevada, where stopping distance tests were conducted at 120°F ambient temperature to determine if the high temperatures coupled with vibration would show up any problems during "SURE-BRAKE" stops.

The road trips, while providing the greatest interest, only occurred after an extensive test program in the Engineering test laboratories where all components were subjected to a wide range of temperature and humidity conditions while cycling at peak loads. The modulators for example are cycled

225,000 times from $-20^{o}$F to $200^{o}$F and special calibration tests are run at $-40^{o}$F and $250^{o}$F.

## THE EFFECT OF VACUUM LEVELS ON PERFORMANCE

The modulators are vacuum powered and as such are dependent on the level of vacuum generated in the engine intake manifold. In general, the tendency of vacuum levels will be to drop during the next few years so this has to be considered in the size of the units. A further consideration is the effect of altitude; the higher one climbs, the lower the vacuum level produced by the engine. In Michigan, at approximately 900 ft. above sea level, vacuum levels of 24" Hg. are readily attained but on top of Pikes Peak in Colorado, at 14,110 feet above sea level, 12" Hg. is a more usual figure. Tests were made descending the Pikes Peak at 20, 30, and 40 MPH in which "SURE-BRAKE" stops were made at each 1,000 ft. vertical drop level when descending and, apart from a tendency for the system to cut out early and lock up the wheels prematurely towards the end of the stops, the systems functioned correctly each time. Since the road is a gravel road and like most mountain roads, twists and turns and has steep grades, the correct functioning of the system at 40 MPH became very important.

## ELECTRO-MAGNETIC INTERFERENCE (E.M.I.)

Much work had to be done in the area to ensure that external sources of energy would not cause failure or unnecessary operation of the system. "SURE-BRAKE" stops were made as close as possible to radio and television towers in the Detroit area, "The Voice of America" station near Cincinnati – one of the most powerful in the country – and at the National Bureau of Standards at Fort Collins, Colorado, where frequencies of 19 Kilohertz to 25 Megahertz are used. No degradation in performance was noted at Detroit or Fort Collins but, while passing under the main supply cable at the "Voice of America" station, a momentary turning off of the system occurred.

Bendix conducted copius tests in the laboratories to cover even wider variations using military specifications as the basis for the test.

## CONCLUSION

The four wheel slip control system has made its debut on a low volume luxurious vehicle but everyone involved in its development is confident that eventually a four wheel system will be standard equipment on all road vehicles. The performance advantages of such a system are now well known. Stopping distances are frequently reduced, stability is preserved and steering control is retained making it possible for the driver to upgrade his performance during those times he is driving at the limit of road to tire adhesion. The "SURE-BRAKE" system will not necessarily help the driver who is not mentally alert and unable to react to an adverse situation. The driver must still steer away from accident situations and apply the brake early and hard enough to stop.

It is not possible to say what wheel slip control systems will be in general use in say ten years time; the field is new and many approaches will no doubt be tried and rejected before arriving at one or two general designs capable of providing satisfactory performance without excessive size, complexity, or weight penalties. Combinations of functions may be achieved; the modulators could be designed to increase brake line pressure as well as reduce it and thus eliminate the power booster. The wheel sensors could provide information to speed control and wheel spin control systems. Other uses for the sensors could be to provide odometer and speedometer input signals.

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Printed in U.S.A.

DEFENDANT'S EXHIBIT 656

December 21, 1964

The Singer Company
30 Rockefeller Plaza
New York, N.Y.

Gentlemen:

The undersigned, in consideration of your execution of an agreement of even date herewith with Perma Research and Development Company, a Delaware corporation, and for other good and valuable consideration, receipt of which is hereby acknowledged, hereby agrees with you as follows:

1. The undersigned shall forthwith assign to you, without additional consideration, all of the undersigned's U.S. and Canadian rights in inventions, U.S. and Canadian patents, U.S. and Canadian patent applications and other U.S. and Canadian rights in improvements of any nature whatsoever relating to the Product (as defined in said agreement between you and Perma Research and Development Company) for the design and manufacture thereof developed by or coming into the possession of the undersigned during the period of time you are obligated to pay royalties to Perma Research and Development Company pursuant to the aforesaid agreement.

2. Upon the expiration of the technical service agreement between you and Perma Research and Development Company, the undersigned shall make himself available to you, at reasonable times, not interfering with the undersigned's

other employment, for consultation and technical assistance in connection with all phases of the design, engineering, manufacture, installation, prototyping and sale of said product so long as such royalties are payable by you. If the undersigned is required to travel at your request to provide such technical assistance, you shall pay the undersigned's cost of transportation, reasonable expenses and per diem of $75 for each day the undersigned is away from his home and performing services for you.

3. The undersigned shall not, directly or indirectly, compete with you in the manufacture or sale of any device designed to prevent the wheels of a motor vehicle from skidding upon application of the brakes thereof or of any substitute or equivalent product during the period such royalties are payable. Indirectly compete includes, without limiting the generality of the foregoing, the entering by the undersigned into employment with a person, firm or corporation making or intending to make such a product, which involves any services by the undersigned in connection with such a product.

If the foregoing correctly sets forth our understanding, please execute a copy of this letter in the place provided below, at which time this shall become a binding agreement between you and the undersigned.

Very truly yours,

/s/ Frank A. Porrino

Frank A. Porrino

Accepted:
The Dinger Company

/s/ E. Hough

EXHIBIT 3(3)

AGREEMENT, dated the 21st day of December, 1964, by and between THE SINGER COMPANY ("Singer"), a New Jersey corporation, and PERMA RESEARCH & DEVELOPMENT COMPANY ("Perma"), a Delaware corporation.

W I T N E S S E T H :

WHEREAS, Perma has simultaneously herewith conveyed certain patents and patent applications relating to the United States and Canadian rights in the "Perma Anti-Skid Control" (the "Product") and certain tools used in the manufacture thereof; and

WHEREAS, Perma has certain testing facilities for the Product and know-how with respect to the manufacture, marketing and use of the Product,

NOW, THEREFORE, in consideration of the premises, the parties agree as follows:

1. Perma shall, at the request of Singer, render technical assistance to Singer which shall include assisting, consulting and cooperating with Singer:

(a) in the adaptation of the Product for use on all makes of automobiles and trucks and all types of motor vehicles of every kind and description;

(b) in the preparation and designing of drawings, blue prints, design sheets, bills of material, speci-

fications and the like from which the Product and its various components can be manufactured, and the preparation of similar documents and materials from which the manufacturing equipment, tools, dies and the like can be made for use in manufacturing the Product;

(c) in the continuing design and engineering and improvement of the Product and of the equipment for manufacturing the same and in the setting up and operation of such equipment, including advice relating to the nature and sequence of manufacturing operations;

(d) in the marketing of the Product; and

(e) in the design and manufacture of prototypes of various new models of the Product for use on various models of automobiles, trucks and other motor vehicles.

2. Perma shall send qualified personnel to the manufacturing facilities of Singer or such other place as Singer may designate from time to time at Singer's request in connection with Perma's obligations under Section 1. The reasonable travel and living expenses of any such personnel shall be paid by Singer. Perma shall during the time of this Agreement make the services of Frank A. Perrino available in connection with its obligation hereunder.

3. Perma shall train selected employees of Singer at the plant and the facilities of Perma with respect to all phases of the manufacture, installation,

marketing and use of the Product.

4. Perma shall install the Product on test cars provided by Singer or Perma and shall perform tests thereon at the testing facilities of Perma as reasonably requested by Singer and shall report to Singer concerning the results of such tests.

5. Singer shall pay Perma $9,800 per month in monthly installments in advance for the services to be performed by Perma hereunder.

6. This agreement shall commence upon the date hereof and shall continue for a term of six months.

IN WITNESS WHEREOF, the parties hereto have executed this agreement, as of the date first above written.

Witness
Attest:
Robert A Kloby

THE SINGER COMPANY

By L E Hough

Attest:
Joseph A Krawczyk

PERMA RESEARCH AND DEVELOPMENT COMPANY

By Frank A. Lerino

DEFENDANT'S EXHIBIT 670

Due to its excessive size, by stipulation dated August 7, 1975, DX 670 (blueprint of vacuum container DC 17-342066-900X) is in the possession of counsel for Defendant. DX 670 will be produced for the Court's inspection upon request.

DEFENDANT'S EXHIBIT 686

Perma Anti-Skid
Detail of Start-up Manufacturing Expenses
July 1 - December 31, 1964

Personnel Costs

| Empl # | Name | Title | Mthly. Salary | Salary Charged to Perma No. of Months | Amount | |
|---|---|---|---|---|---|---|
| 2610 | A. Romel | Manager of Engineering | | 6 | | |
| 9445 | G. Papczun | Mechanical Engineer | | 6 | | |
| 5494 | H. Sharp | Mechanical Engineer | | 6 | | |
| 3696 | F. Gessner Sr. | Mechanical Engineer | | 6 | | |
| 6426 | J. Wagner | Sr. Engineer-Automotive Control Systems | | 4 | | |
| 3315 | C. Fricke | Mechanical Engineer | | 3 | | |
| 2454 | M. Sasileo | Secretary | | 6 | | |
| | | Total Salaries | | | $ 26,565 | |
| | | Fringe Benefits @ 30% | | | 7,970 | |
| | | | | | | $ 34,535 |
| | | Installation of Airlines, Work Benches and Miscellaneous Equipment and Preparation of Area | | | | 3,800 |
| | | Unpacking, Inspecting and Repairing Initial Perma Anti-Skid Inventory | | | | 4,450 |
| | | Training Costs of Assembly Labor | | | | 3,950 |
| | | Travel and Living Expenses | | | | 533 |
| | | Total Start-up Mfg. Expense 1964 | | | | $ 47,268 |

Perma Anti-Skid
Detail of Operating Expenses
For Year 1965

Manufacturing Variances

| | | |
|---|---|---|
| 1. Scrap Value of Defective and Obsolete (Due to Design Changes) Component Parts and Materials | $ 41,000 | |
| 2. Repair and Salvage Costs of Defective Components | 10,294 | |
| 3. Direct Labor Inefficiency | 1,250 | |
| Total Manufacturing Variances | | $ 52,544 |

Inventory Adjustment

| | |
|---|---|
| Physical to Book Unfavorable Adjustment as of 12/31/65. Attributed Primarily to Short Shipments by Vendors | 18,211 |

Manufacturing Period Cost

1. Salaries and Fringe Benefits

| Empl # | Name | Title | Mthly. Salary | Period Worked on Perma 1965 | | Salary Amount Charged To Perma |
|---|---|---|---|---|---|---|
| 2610 | A. Romel | Manager of Eng. | $ | 1/1-12/31/65 | 12 Mos. | |
| 9445 | G. Papczun | Mech. Engineer | | 1/1-12/31/65 | 12 Mos. | |
| 5494 | H. Sharp | Mech. Engineer | | 1/1-12/31/65 | 12 Mos. | |
| 8983 | P. Urban | Mech. Engineer | | 1/1-12/31/65 | 12 Mos. | |
| 6195 | J. Remias | Mech. Engineer | | 1/1-12/31/65 | 12 Mos. | |
| 3696 | F. Gessner Sr. | Mech. Engineer | | 1/1-8/31/65 | 8 Mos. | |
| 6426 | J. Wagner | Sr. Eng. Automotive Control Systems | | 1/1-12/31/65 | 12 Mos. | |
| 4501 | T. Kumor | Mech. Engineer | | 1/1-3/31/65 | 3 Mos. | |
| 9972 | N. Hnojowy | Q.C. Engineer | | 2/1/65-10/4/65 | 9 Mos. | |
| 6718 | G. Chaplenko | Supervisory Chemist | | 2/1/65-8/31/65 | 7 Mos. | |
| 9969 | W. Guiseppi | Plastics Engineer | | 2/1/65-5/31/65 | 4 Mos. | |
| 3315 | C. Fricke | Mech. Engineer | | 1/1/65-9/30/65 | 9 Mos. | |
| 2454 | M. Sasileo | Secretary | | 1/1/65-12/31/65 | 12 Mos. | |
| 9047 | R. Kloby | Dept. Manager | | 1/1-12/31/65 | 12 Mos. | |
| | | Total Salaries | | | | |
| | | Fringe Benefits @ 29.75% | | | | |
| | | Total Salaries and Benefits | | | | $ 137,764 |

| | | |
|---|---|---|
| 2. Charges from Denville, N.J. Laboratory | 13,354 | |
| 3. Technical Services - Perma 5 Mos. @ $9,800. | 49,000 | |
| 4. Occupancy and Utility Expenses - 30,000 Square Feet @ 1.47/ft/yr | 44,000 | |
| 5. Cancellation Costs - American Optical Company | 40,604 | |
| Total Manufacturing Period Cost | | 284,722 |
| Allocation of Administrative Cost | | 26,572 |
| Total Operating Expense - 1965 | | $ 382,049 |

DEFENDANT'S EXHIBIT 687

SINGER CONFIDENTIAL DX687

EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Feb. 20, 6

DX 687 DX 677-74

| FULL NAME | SOCIAL SECURITY NO |
|---|---|
| Albert E. Romel | 158-22-9177 |
| HOME ADDRESS | TEL. NO |
| 31 Scheid Drive | 201 727-6295 |
| Parlin, New Jersey | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 4/24/31 | Elizabeth, N.J. | 35 | 5/10/51 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| U.S.A. | | Elizabeth, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE Oct. 1965 |
|---|---|---|---|---|
| Blue | Brown | 5'11 | 204 | CONDITION OF HEALTH Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Anna Di Georgio | June 15, 1958 |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth, N.J. | U.S.A. | |

| PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) | AGES AND SEX OF CHILDREN | |
|---|---|---|
| Elizabeth, N.J. | MALE | 2 2 2 |
| | FEMALE | 1 |

**MILITARY SERVICE RECORD**

| DATE OF ENTRY | BRANCH OF SERVICE |
|---|---|
| 12/8/55 | ARMY |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| 9/13/55 | Honorable |

| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
|---|---|
| Camp Pickatta Va. | Corporal |
| Ft. Bliss Texas | Spec. 3rd. Cl. |
| Ft. MacArthur, California | |
| | Spec. 3rd Cl. |

**HOBBIES AND INTERESTS**

Church Activities
Reading
Woodworking
Gardening
Fishing

**LANGUAGES OTHER THAN ENGLISH**

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

**GEOGRAPHIC PREFERENCE JOB AREAS**

| CHOICE | STATE | CITY |
|---|---|---|
| 1ST | New Jersey | |
| SECOND | Northeastern, U.S.A. | |
| 3RD | West Coast | |
| FOURTH | | |
| PAYMENTS | | |

**EDUCATIONAL BACKGROUND**

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Thomas Jefferson | Elizabeth, N. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 3 | June 1949 | Gen. Arts |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL
Sports

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Newark College of Engineering | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 8 (Evenings) | June 1964 | Engr. | B.S.M. |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING Nike Guided Missile School, Ft. Bliss, Texas-Singer Evening School (App. Prog

SINGER
CONFIDENTIAL

[DX 687, p 2]

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED 1/10 [illegible]

FULL NAME: George John Kapczun

SOCIAL SECURITY NO: 140-16-1953

HOME ADDRESS: 19 Furber Avenue

TEL NO.: HU 6-1677

Linden, New Jersey

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 7/20/27 | Elizabeth, N. J. | 38 | 5/25/63 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| U.S.A. | | Linden, N. J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION OF HEALTH |
|---|---|---|---|---|---|
| Hazel | Brown | 5' 10" | 150 | 1964 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

WIFE'S MAIDEN NAME IN FULL: Mary Valiska

DATE OF MARRIAGE: June 14, 1952

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Czechoslovakia | U.S.A. | Czechoslovakia |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Linden, N. J.

AGES AND SEX OF CHILDREN: MALE 5; FEMALE 1, 3, 2

## MILITARY SERVICE RECORD

| DATE OF ENLISTMENT | BRANCH OF SERVICE |
|---|---|
| 10/3/45 | U.S. Army |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| 12/2/46 | Honorable |

| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
|---|---|
| Occupational | PFC |
| Counselor Unit | Sec. 5 |
| | |
| | |
| | RANK AT DISCHARGE |

## HOBBIES AND INTERESTS

Coin Collection
Stamp Collection
Church Work

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| Slovak | | X | | X |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CODE | STATE | CITY |
|---|---|---|
| 1st | Union County, New Jersey | |
| 2nd | New Jersey | |
| 3rd | New York | |
| 4th | Non-Eastern States | |
| Overseas | | |

## EDUCATIONAL BACKGROUND

HIGH SCHOOL ATTENDED: Linden High School — LOCATION: Linden, N. J.

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | June 1945 | College Prep |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL
Math Club
Interclass Basketball

COLLEGE OR UNIVERSITY ATTENDED: Newark College of Engineering — LOCATION: Newark, N. J.

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| Eight (Nights) | June 1956 | Mech. Engr. | B.S.M.E. |

GRADUATE SCHOOL ATTENDED: None — LOCATION:

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES
None

OTHER SPECIALIZED SCHOOLS OR TRAINING
None Newark College Engrg - Programming [illegible]

E-1257

SINGER
CONFIDENTIAL

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Jan. 27, 19

FULL NAME: Hermann Henry Sharp
SOCIAL SECURITY NO: 153-09-9457
HOME ADDRESS: 122 Walnut Street ✓
TEL NO: 245-1655
Roselle Park, N.J.

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 5/27/20 | Easton, Penna. | 39 | 1940 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Roselle Park |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL |
|---|---|---|---|---|
| Gray-Green | Lt.Brown | 5'7" | 165 | CONDITION OF HEALTH: Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

WIFE'S MAIDEN NAME IN FULL: Vivian Maria Wittfield — DATE OF MARRIAGE: Jan.5,1946
WIFE OR HUSBAND'S PLACE OF BIRTH: Hoboken,N.J. — WIFE OR HUSBAND'S PRESENT CITIZENSHIP: American — WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT):
PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Newark,N.J.
AGES AND SEX OF CHILDREN: MALE; FEMALE

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| 12/7/42 | Army Air Force |
| DATE OF DISCHARGE: 10/27/45 | TYPE OF DISCHARGE: Honorable |
| ASSIGNMENT OR SERVICE: Flight Cadet | PROMOTIONS IN SERVICE |
| Course Penn St | |
| Course Engr. | CPL |
| Reading Course | SGT |
| Lead Course | S/SGT-Tech.SGT |
| Curriculum Med. | Tech.Sgt. |

## HOBBIES AND INTERESTS

Woodworking, Model Making
Stamp & Coin Collecting,
Photography, Fishing,
Swimming, Sailing, all Sports

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| Spanish | | X | | X |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| FIRST | New Jersey | Elizabeth |
| SECOND | Calif. | San Diego |
| THIRD | Florida | Miami |
| FOURTH | | |

COMMENTS

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Roselle Park High | Roselle Park,N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | June, 1939 | General w/ Col.Course Subj. |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL
Varsity Baseball, Wrestling
Intramural Basketball & Indoor Track
Aviation Club, Spanish Club, Math. Club

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| | | | |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

U.C.L.A.(U/C Dgs.) Lead.Chemistry

OTHER SPECIALIZED SCHOOLS OR TRAINING
Deforrest Inst.Radio .Aerial Engr.course (3 mo.

E-1258

CONFIDENTIAL

[DX 687, p 4]

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Jan.10 19

FULL NAME: Paul Louis Urban

SOCIAL SECURITY NO: 156-29-0622

HOME ADDRESS: 13 Park Terrace

TEL. NO: 272-6810

Cranford, N.J. 07016

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 12/29/33 | Jersey City, N.J. | 24 | 12/61 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Palisades Park |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION OF HEALTH |
|---|---|---|---|---|---|
| Blue | Brown | 5'8" | 170 | 1/63 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☑ MARRIED ☐ SEPARATED ☐ WIDOWED

WIFE'S MAIDEN NAME IN FULL: Patricia Ann McQuillian — DATE OF MARRIAGE: 1/7/57

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Englewood, NJ | American | |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Englewood

AGES AND SEX OF CHILDREN: MALE 7; FEMALE 5, 2

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| 6/59 | U.S.N.R. |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| 12/64 | |
| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
| Cook | |
| Aboard USS [illegible] | |
| | |
| | |
| | RANK AT DISCHARGE |
| | SK |

## HOBBIES AND INTERESTS

Fishing
Scouting Work

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| SOURCE | [illegible] | STATE | CITY |
|---|---|---|---|
| [illegible]ST | | | |
| [illegible]CORD | | | |
| [illegible]ED | | | |
| [illegible]RTH | | | |
| [illegible]MENTS | | | |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Leonia High School | Leonia, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 3 | June, 1956 | College |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL

Football
Wrestling

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Newark College of Engineering | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 4 | 6/60 | Mech. Engr. | B.S.M.E. |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| Rutgers- The State University | New Brunswick |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING

E-1259

CONFIDENTIAL

[DX 687, p 5]

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED: Jun. 27, 6

FIRST NAME: John Robert Remias

SOCIAL SECURITY NO.: 147-38-6453

HOME ADDRESS: 130A Roanoke Street

TEL. NO.: 636-9171

Woodbridge, N. J.

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 1/10/38 | Rahway, N.J. | 27 | 6/25/56 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Colonia, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL |
|---|---|---|---|---|
| Blue | Brown | 5'10" | 170 | July, 1954 |

Condition: Excellent

☐ SINGLE ☒ MARRIED ☐ DIVORCED ☐ SEPARATED ☐ ENGAGED ☐ WIDOWED

## MILITARY SERVICE RECORD

| DATE OF ENLISTMENT | BRANCH OF SERVICE |
|---|---|
| 8/7/52 | Army |
| **DATE OF DISCHARGE** | **TYPE OF DISCHARGE** |
| 8/5/54 | Honorable |

| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
|---|---|
| 766th Engr. Battalion | PFC |
| | Specialist 4th Class |
| | Sergeant 1st Class |

WIFE'S MAIDEN NAME IN FULL: Kathleen Maria Sullivan

DATE OF MARRIAGE: May 8, 1965

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth | American | |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Elizabeth, N.J.

AGES AND SEX OF CHILDREN: MALE ; FEMALE

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Woodbridge High School | Woodbridge, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | June, 1956 | Sec. Scientific |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL: Audio-Visual Technician

## HOBBIES AND INTERESTS

Numismatics
Hunting
Fishing

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| FIRST | New Jersey | Elizabeth |
| SECOND | | |
| THIRD | | |
| FOURTH | | |

COLLEGE OR UNIVERSITY ATTENDED: — LOCATION:

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| | | | |

GRADUATE SCHOOL ATTENDED: — LOCATION:

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES:

OTHER SPECIALIZED SCHOOLING OR TRAINING: ~~2 yrs. Toolmaker Apprentice, 1 Yr~~ Mech. Trainee, 3 Yrs. Mech. Design Cert. N.C.E. Certificate-Electrical Technology, NCE, June, 1970.

E-1260

SINGER CONFIDENTIAL

FORM 64-1013

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED March

FULL NAME: Gessner, Frank

SOCIAL SECURITY NO.: 139-10-26[illegible]

HOME ADDRESS: 8 Cedar Waxwing

TEL. NO.: 852-1734

Hackettstown, New Jersey 07840

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 12-02-10 | Elizabeth, N.J. | 0 | 2-17-2[illegible] |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | --- | Elizabeth, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION HEALTH |
|---|---|---|---|---|---|
| Blue | Brown | 5' 7½" | 150 | 1956 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED –
☒ MARRIED ☐ SEPARATED ☐ WIDOWED –

WIFE'S MAIDEN NAME IN FULL: Rose Freisinger — DATE OF MARRIAGE: October 3, 193[illegible]

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth | American | – |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Kingwood, New Jersey

AGES AND SEX OF CHILDREN: MALE –; FEMALE 3[illegible]

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| | None |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| | |
| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
| – | – |
| | |
| | |
| | |
| | |
| | RANK AT DISCHARGE |

## HOBBIES AND INTERESTS

Bowling
Football
Gardening
Baseball

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| German | | X | | X |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| FIRST | New Jersey | Elizabeth |
| SECOND | New Jersey | Finderne |
| THIRD | So.Carolina | Anderson |
| FOURTH | | |

COMMENTS

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Singer Evening School | Elizabeth, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | 1931 | Toolmaker Apprentice |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Newark College of Engineering | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 2 | | | |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES: Human Relations Course Management Development Executive Foremen's Clu[illegible] Executive Development Conferences N.C.E. Special Courses Division

OTHER SPECIALIZED SCHOOLS OR TRAINING

SINGER CO. CONFIDENTIAL

[DX 687, p 7]

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED December 17,

| FULL NAME | SOCIAL SECURITY NO. |
|---|---|
| Wagner, John Peter | 136-20-2929 |
| HOME ADDRESS | TEL. NO. |
| 780 Layton Drive | 688-2650 |
| Union, New Jersey | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 1-10-23 | Elizabeth, N.J. | 37 | 1940 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Union, New Jersey |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION OF HEALTH |
|---|---|---|---|---|---|
| Blue | Blond | 5'2 | 190 | 1957 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Mary Ann Hock | May 15, 1952 |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth | U.S. | |

| PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) | AGES AND SEX OF CHILDREN | | |
|---|---|---|---|
| Elizabeth, New Jersey | MALE | 9 | 4 |
| | FEMALE | | |

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
| | |
| | |
| | |
| | |
| | RANK AT DISCHARGE |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Union High School | Union, New Jersey |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | 1956 | General |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Newark College of Engineering | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 3 | 1957 | | Cert. |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

COURSES CHANGED SINCE GRADUATION
Radio & Television
Singer Evening School

## HOBBIES AND INTERESTS

Electrical

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | AREA | CITY |
|---|---|---|
| FIRST | [illegible] | Elizabeth |
| SECOND | [illegible] | Elizabeth |
| THIRD | [illegible] | Elizabeth |
| FOURTH | [illegible] | Elizabeth |

REMARKS

[DX 687, p 8]

SINGER CONFIDENTIAL

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Oct. 10, 1

FULL NAME: Thaddeus Kumor

SOCIAL SECURITY NO: 144-01-4091

HOME ADDRESS: 102 Lefferts Lane

TEL NO: 381-2809

Clark, New Jersey

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 8-5-17 | Elizabeth, N.J. | 13 | 1947 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Elizabeth, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION OF HEALTH |
|---|---|---|---|---|---|
| Blue | Brown | 5' 10½" | 180 | 1965 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

WIFE'S MAIDEN NAME IN FULL: Julia E. Ostrowski

DATE OF MARRIAGE: Nov. 25, 1945

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth, N.J. | American | |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20): Elizabeth, N.J.

AGES AND SEX OF CHILDREN: MALE 11; FEMALE 9

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| Feb. 23, 1943 | U.S.A.A.F. |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| Oct. 15, 1945 | Honorable |
| ASSIGNMENTS IN SERVICE | RANK OR RATING IN SERVICE |
| Bombardier | 1st Lt. |
| Present: | |
| Ground Equip. Maint. Off. | Lt. Col. (Res.) |
| | RANK AT DISCHARGE: 1st Lt. |

## HOBBIES AND INTERESTS

Committeeman - Scouting
Treasurer - Cub Scouting

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| Polish | X | | | X |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CITY OR ZONE | STATE | CITY |
|---|---|---|
| FIRST | | |
| SECOND | | |
| THIRD | | |
| FOURTH | | |
| REMARKS | | |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Thomas Jefferson | Elizabeth, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | 1936 | Scientific Metal Working |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL: Track, Orchestra

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Rutgers University | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 5 (Evenings) | 1956 | Mgmt. | B.S. |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING: Union Jr. College - Assoc. Engr. - 1951

E-1263

[DX 687, p 9]

CONFIDENTIAL

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Dec. 21, 1945

| FULL NAME | SOCIAL SECURITY NO |
|---|---|
| Nestor Hnojowy | 097-07-2037 |
| HOME ADDRESS | TEL NO. |
| 2179 Bright Ave. | 51b FR-5-3041 |
| East Meadow, Long Island, New York | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 1/11/17 | Brooklyn, N.Y. | 17 | April 193[illegible] |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| U.S.A. | | Elmont, L.I., N.Y. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION HEALTH |
|---|---|---|---|---|---|
| Grey | Brown | 5' 8" | 151 | Sept. 1935 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Doris J. Morsand | 11/33/1944 |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Northampton, Mass. | U.S.A. | |

PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20)
Northampton, Mass.

AGES AND SEX OF CHILDREN: MALE 13; FEMALE

## MILITARY SERVICE RECORD

| | |
|---|---|
| March 1941 | BRANCH Air Force |
| DATE OF DISCHARGE Sept. 1945 | TYPE OF DISCHARGE Honorable |
| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
| Hawaii | |
| S. Pacific | |
| Pueblo, Colo. | |
| Hicopee, Mass. | |
| | RANK AT DISCHARGE S/Sgt. |

## HOBBIES AND INTERESTS

Home Gardening
Sports
USO

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| Ukranian | | X | | X |
| Polish | | X | | X |
| Russian | | X | | X |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CITY | STATE |
|---|---|
| New York, N.Y.C. | |
| New Jersey, Elizabeth | |
| North Eastern U.S.A. | |
| Central U.S.A. | |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Sewanhaka, H.S. | Floral Park, L.I., N.Y. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | June 1935 | Commercial |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL
Various Sports
Music

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION | | |
|---|---|---|---|
| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
| GRADUATE SCHOOL ATTENDED | LOCATION | | |
| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING

E-1264

[DX 687, p 9]

# APPLICATION FOR EMPLOYMENT
## THE SINGER MANUFACTURING COMPANY
### ELIZABETHPORT WORKS
### ELIZABETHPORT P, NEW JERSEY

3-17-56

## SONAL INFORMATION

NAME IN FULL [illegible] (LAST) (FIRST) (MIDDLE) — IF FEMALE AND MARRIED MAIDEN NAME

ES (NUMBER AND STREET) (CITY) (STATE) — HOME (OR NEAREST) TELEPHONE NUMBER

SECURITY NO. 147-21-4316 — DATE OF BIRTH [illegible] 1924 — AGE 32 — MALE ☐ FEMALE ☐

5 (FEET) 11 (INCHES) — WEIGHT 175 (POUNDS) — RIGHT HANDED ☑ LEFT HANDED ☐

L STATUS [illegible] — FIRST NAME OF WIFE OR HUSBAND [illegible] — NUMBER OF DEPENDENTS [illegible]

R WIFE OR HUSBAND OYED. BY WHOM [illegible] — WHERE (NUMBER AND STREET) (CITY) (STATE)

U RELATED TO ANYONE YED BY THIS COMPANY — YES ☐ NO ☑ — IF YES, TO WHOM — RELATIONSHIP

YOU EVER EMPLOYED BY THIS COMPANY, SINGER G MACHINE CO., DIEHL MFG. CO., OR ANY AFFILIATE — YES ☐ NO ☐ — IF YES, WHERE — WHEN

U A CITIZEN OF THE UNITED STATES — YES ☑ NO ☐ — FOREIGN LANGUAGES SPOKEN [illegible]

E OF EMERGENCY NOTIFY [illegible] (NAME) (ADDRESS) (RELATIONSHIP) (TELEPHONE NO.)

## ICATIONAL HISTORY

| SCHOOL | LOCATION | YEARS ATTENDED | DATE LEFT | GRADUATED (YES OR NO) | COURSE | DEGREE |
|---|---|---|---|---|---|---|
| [illegible] Gymnasium | [illegible] Ukraine | 12 | 1941 | yes | [illegible] | — |
| [illegible] Institute | [illegible], Ukraine | 2 | 1944 | no | St. Engg. | — |
| [illegible] University | New Brunswick N.J. | 4 | 1955 | yes | Chemistry | B.S. |
| [illegible] [illegible] | America, Germany | 1/2 | 1965 | yes | Language | Ph.D. |

AL TRAINING [illegible]

## PLOYMENT HISTORY — LIST BELOW YOUR FORMER EMPLOYERS — START WITH LAST POSITION

| EVIOUSLY EMPLOYED BY | ADDRESS | YEARS OF SERVICE | DATE LEFT | RATE OF PAY | NATURE OF WORK | REASON FOR LEAVING |
|---|---|---|---|---|---|---|
| [illegible] Chemical | Linden, N.J. | 4 | [illegible] | $2.1 | [illegible] | [illegible] |
| | | | >1 | | [illegible] | [illegible] |
| — [illegible] — | — [illegible] — | 2 | [illegible] | $1.91 | Chemist | [illegible] |
| [illegible] | [illegible] | 1/2 | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | | [illegible] | 1.25 | | [illegible] |
| | | | | | | |
| | | | | | | |

## ITARY SERVICE RECORD

CH OF SERVICE — DATE OF SERVICE: FROM — TO

WHEN DISCHARGED — TYPE OF DISCHARGE — ANY SERVICE DISABILITY YES ☐ NO ☐

S USED OR SPECIAL TRAINING

## YSICAL AND MEDICAL HISTORY

YOU WILLING TO SUBMIT TO A PHYSICAL EXAMINATION BY THE COMPANY DOCTOR YES ☑ NO ☐

T IS THE PRESENT DITION OF YOUR HEALTH Good — IS YOUR EYESIGHT DEFECTIVE YES ☐ NO ☐ — IS YOUR HEARING DEFECTIVE YES ☐ NO ☐

E YOU ANY OTHER SICAL DEFECTS YES ☐ NO ☐ IF YES, EXPLAIN 3-20-56: PHYSICAL DEFECTS: MUST WEAR GLASSES AT ALLTIMES ON CO. PROPERTY. No ~~xxx~~ other phys. defects. sk

E YOU EVER HAD OPERATIONS YES ☐ NO ☐ IF YES, STATE EACH BRIEFLY

E YOU EVER HAD ANY SERIOUS ESS OR INJURIES YES ☐ NO ☐ IF YES, STATE EACH BRIEFLY

E YOU EVER RECEIVED KMEN'S COMPENSATION YES ☐ NO ☐ IF YES, WHEN WHERE

## PLICANT'S DECLARATION

CERTIFY THAT THE ABOVE STATEMENTS ARE TRUE. IF ANYTHING CONTAINED IN MY APPLICATION IS FOUND TO BE UNTRUE, CONCEALED, OMITTED. I UNDERSTAND THAT I WILL BE SUBJECT TO DISMISSAL.

SIGNED Geo. Chapleau

ECEIVED FROM THE SINGER MANUFACTURING COMPANY THE FOLLOWING BOOKLETS WHICH I HAVE CHECKED BELOW.

RETIREMENT PLAN ☑ EMPLOYEES BENEFIT PLAN ☑ COMPANY RULES ☑ UNION CONTRACT ☐

TE 3/20 19 56 SIGNED Geo. Chapleau 45

APPLICANT—PLEASE DO NOT WRITE BELOW THIS LINE

## PARTMENT INTERVIEW

| PT. | REQUISITION NUMBER | JOB | REMARKS | INTERVIEWER |
|---|---|---|---|---|
| | | | | |
| | | | | |

BER 65 CHECK NUMBER U436 STARTING DATE 19 STARTING TIME A.M. P.M.

PATION L. G. DAY WORK ☐ INCENTIVE ☐ SALARY ☐ RATE OF PAY $

IT IS UNDERSTOOD, THAT MY EMPLOYMENT WITH COMPANY IS OF A TEMPORARY NATURE AND WILL E 19

ED APPROVED BY DEPARTMENT MANAGER

## YSICAL EXAMINATION REPORT

Satisfactory for employment

E 3-20-56 APPROVED BY EXAMINING PHYSICIAN H. E. Crowell

## RSONNEL INTERVIEWER'S REMARKS

C.D. Mills Hire-Ugw

Will be 3- leg Inventory Clerk

A new job will be made. Salary

Ugw/Mc Co-Inv. Sept. 2

at Mo. Rate 60.00 pr week 3/12/56

SIGNED Geo. Cole

E-1266 [DX 687, p 11]

SINGER CONFIDENTIAL

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED Feb. 20,

| FULL NAME | SOCIAL SECURITY NO |
|---|---|
| William P. Guinoppi | 145-03-691 |
| HOME ADDRESS | TEL. NO. |
| 730 Hart Drive | 722-5893 |
| Somerville, N.J. | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 10/18/15 | Boonton, N.J. | 50 | 10-24-60 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Boonton, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL |
|---|---|---|---|---|
| Brown | Brown | 5'8 | 175 | 1-1967 |
| | | | | GENERAL HEALTH: Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☑ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Claire A. Stackhouse | June 7, 1941 |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Boonton, N.J. | American | |

| PLACE WIFE OR HUSSAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) | AGES AND SEX OF CHILDREN | |
|---|---|---|
| Boonton, N.J. | | MALE |
| | | FEMALE 20 17 1 |

## MILITARY SERVICE RECORD

| DATE ENTERED | BRANCH OF SERVICE |
|---|---|
| Feb. 1943 | Army Air Force |
| DATE DISCHARGED | HONORABLE |
| Dec. 1945 | Honorable |

| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
|---|---|
| Radio Oper. | CPL |
| Aerial Gunner | SGT |
| Number Combat Crew ETO | S/SGT |
| | RANK AT DISCHARGE |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Boonton | Boonton |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 4 | June, 1936 | General |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL: Participated in Varsity Football, Baseball, Basketball, Number Language Club ( Spanish) Pres. Officer In Student Regalian Assoc.

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| | | | |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGE

OTHER SPECIALIZED SCHOOLS OR TRAINING: Completed N.J. State Supervisory Courses Completed Motion Engr. Courses at

## HOBBIES AND INTERESTS

Golf
Landscaping
Working w/ Young boys interested in athletics

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| Italian | X | | | X |
| Spanish | | X | | X |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| First | New Jersey | |
| Second | Japan | |
| Third | Italy | |
| Fourth | Scotland | |

Prefer to live in NJ Until our children finish school.

[DX 687, p 13]

SINGER CONFIDENTIAL
FORM 68-1013

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED July, G

| FULL NAME | SOCIAL SECURITY NO. |
|---|---|
| Fricko, Charles Robert | 156-22-1523 |
| HOME ADDRESS | TEL. NO. |
| 71 E. Cliff Road | 382-1874 |
| Colonia, New Jersey | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 0/2/29 | Elizabeth, New Jersey | 14 | 1947 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| American | | Elizabeth, N.J. |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION OF HEALTH |
|---|---|---|---|---|---|
| Brown | Black | 5'10 | 175 | Nov.57 | Excellent |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Patricia J. Bialas | - - |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth, N.J. | American | |

| PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) | AGES AND SEX OF CHILDREN | |
|---|---|---|
| Elizabeth, New Jersey | MALE | 4 10 12 |
| | FEMALE | 2 6 - |

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| 1951 | U.S. Army |
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| 1953 | Honorable |

| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
|---|---|
| Leadership Sch. | Cpl. |
| O.C.S. | SGT. |
| Ski Troops | |
| | RANK AT DISCHARGE SGT. |

## HOBBIES AND INTERESTS

Arts & Crafts
Sports

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| FIRST | New Jersey | Elizabeth |
| SECOND | | |
| THIRD | | |
| FOURTH | | |
| COMMENTS | | |

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Thomas Jefferson High School | Elizabeth, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 3 | 1947 | General Arts |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Pace College | New York City |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 1 | | | |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| | |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| | | |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING

N.C.E.-Control Devices as applied to Auto. Equip.

E-1268

[DX 687, p 14]

SINGER
CONFIDENTIAL
FORM 58-1015

# EMPLOYEE HISTORY AND COMPENSATION RECORD

PREPARED May 10, [illegible]

| FULL NAME | SOCIAL SECURITY NO. |
|---|---|
| Kloby, Robert Anthony | 150-26-0329 |
| HOME ADDRESS | TEL. NO. |
| 854 Pine Street | 241-2374 |
| Roselle, New Jersey 07203 | |

| DATE OF BIRTH | PLACE OF BIRTH | NUMBER YEARS IN PRESENT AREA | DATE EMPLOYED BY SINGER |
|---|---|---|---|
| 9-20-31 | Newark, New Jersey | 39 | 10-8-53 |

| PRESENT CITIZENSHIP | CITIZENSHIP AT BIRTH (IF DIFFERENT) | PLACE RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) |
|---|---|---|
| U.S. | --- | Elizabeth, New Jersey |

| COLOR OF EYES | COLOR OF HAIR | HEIGHT | WEIGHT | DATE LAST PHYSICAL | CONDITION HEALTH |
|---|---|---|---|---|---|
| Blue | Brown | 5'10 | 190 | Oct., 1960 | Good |

☐ SINGLE ☐ DIVORCED ☐ ENGAGED
☒ MARRIED ☐ SEPARATED ☐ WIDOWED

| WIFE'S MAIDEN NAME IN FULL | DATE OF MARRIAGE |
|---|---|
| Ann Marie Carroll | 9-07-57 |

| WIFE OR HUSBAND'S PLACE OF BIRTH | WIFE OR HUSBAND'S PRESENT CITIZENSHIP | WIFE OR HUSBAND'S CITIZENSHIP AT BIRTH (IF DIFFERENT) |
|---|---|---|
| Elizabeth, N.J. | U.S. | -- |

| PLACE WIFE OR HUSBAND RAISED (SPENT MOST YEARS BETWEEN AGES 10 AND 20) | AGES AND SEX OF CHILDREN | | |
|---|---|---|---|
| Elizabeth, New Jersey | MALE | 0 | |
| | FEMALE | 11 | |

## MILITARY SERVICE RECORD

| DATE OF ENTRANCE | BRANCH OF SERVICE |
|---|---|
| DATE OF DISCHARGE | TYPE OF DISCHARGE |
| ASSIGNMENTS IN SERVICE | PROMOTIONS IN SERVICE |
| | |
| | |
| | |
| | |
| | RANK AT DISCHARGE |

## HOBBIES AND INTERESTS

Sports

## LANGUAGES OTHER THAN ENGLISH

| LANGUAGE | SPOKEN FLUENTLY YES | SPOKEN FLUENTLY NO | WRITTEN YES | WRITTEN NO |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## GEOGRAPHIC PREFERENCE JOB AREAS

| CHOICE | STATE | CITY |
|---|---|---|
| FIRST | New Jersey | Elizabeth |
| SECOND | New York | New York |
| THIRD | | |
| FOURTH | | |

COMMENTS

## EDUCATIONAL BACKGROUND

| HIGH SCHOOL ATTENDED | LOCATION |
|---|---|
| Thomas Jefferson | Elizabeth, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | TYPE COURSE |
|---|---|---|
| 3 | June, 1949 | College Prep. |

EXTRA CURRICULAR ACTIVITIES IN HIGH SCHOOL

Varsity Track - Cross Country and Wrestling

| COLLEGE OR UNIVERSITY ATTENDED | LOCATION |
|---|---|
| Seton Hall University | So.Orange, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | MAJOR | DEGREE |
|---|---|---|---|
| 5 | June, 1954 | Mgmt. | B.S. |

| GRADUATE SCHOOL ATTENDED | LOCATION |
|---|---|
| Seton Hall University | Newark, N.J. |

| NUMBER OF YEARS ATTENDED | DATE, IF GRADUATED | DEGREE |
|---|---|---|
| 3 | June, 1959 | MBA (Mkt'g.) |

EXTRA CURRICULAR ACTIVITIES IN COLLEGES

OTHER SPECIALIZED SCHOOLS OR TRAINING



[DX 687, p 14]

DEFENDANT'S EXHIBIT 688

(PAGE 909 THROUGH PAGE 910 TO "MEASUREMENT METHODS") 690214

# Measurement of Tire Brake Force Characteristics as Related to Wheel Slip (Antilock) Control System Design

**J. L. Harned, L. E. Johnston, and G. Scharpf**
Engineering Staff, General Motors Corp.

ABSTRACT

Tire brake force characteristic data are presented that should be helpful in the design of wheel slip control systems. Correlation of these data has been established with antilock system performance. Experimentally measured $\mu$-slip curves are given for a large number of tire/road pairings. These measurements cover a wide range of commercial tire types on dry and wet road surfaces and glare ice. It is shown how wet road characteristics are affected by road construction, water cover depth, and tread wear. The measuring system used to obtain these data is described and variability of the experimental measurements is discussed.

WHEEL SLIP (antilock) control systems must be designed so that they can successfully adapt to the wide environment that the automobile operates in. One of the major difficulties that these systems must contend with is the large variations in tire brake force characteristics caused by such factors as road surface construction and contaminants, tire parameters and tread wear, and vehicle speed. At present, the amount of quantitative tire brake force versus wheel slip data that describe automobile tires operating under frequently encountered road conditions is limited. The purpose of this paper is to fill this void partially by providing tire brake force characteristic data measured over a wide range of road/tire pairings and vehicle speeds. These data should be helpful to the automotive engineer in his efforts to refine present antilock systems to up-grade their performance and to develop new improved antilock systems.

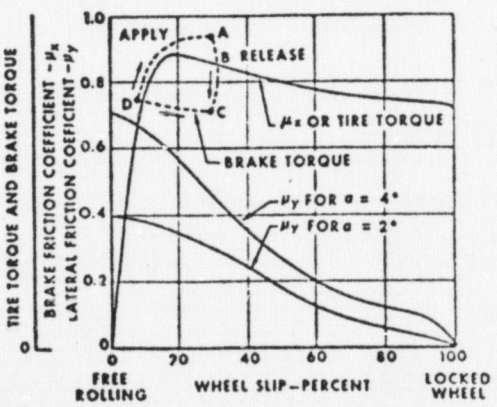


**Fig. 1** - Representative tire brake force and lateral force as functions of wheel slip

## TIRE CHARACTERISTICS

The potential of new brake devices, such as antilock systems, to improve vehicle braking performance arises from the tire $\mu$-slip characteristic. One $\mu$-slip curve that is representative of a tire being braked on a high coefficient of friction surface is shown in Fig. 1. Along the ordinate is plotted brake force coefficient, $\mu$, which is the ratio of tire brake force at the tire-road interface divided by the normal load acting on the tire. Wheel slip, $\sigma$, is defined as

$$\sigma = \frac{u - \omega Re}{u} \qquad (1)$$

where:

u = Vehicle forward velocity, fps
ω = Wheel angular velocity, rad/sec
Re = Tire effective rolling radius (free rolling), ft

Thus, zero slip represents the free rolling wheel condition while 100% slip corresponds to a wheel that is locked up and sliding.

There are three characteristics of the tire which are significant to the antilock control problem. First, the ratio of peak brake force coefficient to the locked wheel value indicates the potential of an antilock system to decrease stopping distance relative to that achieved with locked wheels. Conversely, for those tire/road pairings where the peak brake force coefficient occurs at 100% slip, the ratio of the brake force coefficient at the knee of the curve to the locked wheel value reflects the degree that vehicle stopping distance may be increased when braking with antilock control.

Secondly, the negative slope immediately following the peak in the μ-slip curve has an important bearing on the efficiency of the antilock system. This relationship can be readily demonstrated by considering the operation of an antilock system based on the extremal control principle. The brake torque limit cycle trajectory for a simple extremal control antilock system (1)* is shown in Fig. 1. Brake torque slowly increases from D to A. Incipient wheel lockup is signalled when the brake torque reaches A which causes the antilock system to release brake torque rapidly. The time for brake torque to decrease from A to B is dependent upon the negative slope and it increases as this slope becomes larger. Increasing the transition time from A to B allows the wheel slip swing to become larger, which places the intercept point B further down on the μ-slip curve. Mean brake torque maintained by the antilock control is decreased as B moves down the backside of the curve.

The third important tire characteristic is that dealing with the effect that wheel slip has on tire lateral force capability. This interaction directly affects vehicle directional control and/or stability during panic braking. The effect that wheel slip has on both the cornering stiffness and maximum lateral force are important. As shown in Fig. 1, these two tire parameters decrease with increasing wheel slip.**

*Numbers in parentheses designate References at end of paper.

**Lateral force curves are derived from Ref. 7.

DEFENDANT'S EXHIBIT 689
(PAGE 288 "ABSTRACT", PAGE 299 "BRAKING AND SAFETY" THROUGH PAGE 306, PAGE 317 "AUTOMATIC REGULATION DEVICES" THROUGH PAGE 318)

70037

# Automatic Brake Proportioning Devices

# Les Dispositifs de Règlage Automatique du Freinage

# Automatische Bremskraftregler

Giuseppe Pule
FIAT S.p.A.

ABSTRACT

Among the most interesting devices introduced in modern passenger car braking systems, the so called "Brake Proportioners" have marked the beginning of a new era which is bound to have even more resounding developments than enjoyed in the past decade by the disc brakes.

The usefulness of the devices in question is easily demonstrable through a theoretical analysis of the braking problem, analysis which permits to establish also what are the requirements, features, possibilities and limits of the present and future proportioning systems.

A survey of the numerous devices used or proposed so far discloses the variety of trends followed in this particular sector of braking technique and highlights, among other things, the extreme simplicity of some devices in relation to the importance of the functions performed and the remarkable results they permit to attain.

After overcoming the pioneering stage and encouraged by the flattering successes obtained, the studies on automatic brake proportioning are now progressing at full pace. The main goal of this second stage should be the finalization of automatic proportioning devices apt to control the slippage of the individual wheels, with cost, reliability and flexibility characteristics permitting their general adoption on mass production cars.



E-1272

PAGE 299 "BRAKING AND SAFETY" THROUGH PAGE 306

BRAKING AND SAFETY. Two words that since the beginnings of the motor car have always and rightly been considered intimately linked together, if not synonims. The low performance of early automobiles, especially with reference to maximum speed, and a kind of unconfessed fear man felt, when confronted by the magic power emanating from the new machines, fully justified the identification of the car safety problem with that of braking. In fact, it seemed then obvious that the only warranty of safety during any emergency should lie in the possibility of stopping the vehicle in the shortest possible time. This because a car in motion was in itself sufficient for its occupants to be thought of as exposed to the threat of impending danger.

With the technical evolution of the motor car the braking problem, above all in relation to that of safety, has not only maintained its initial importance, but has aroused ever-increasing as a consequence of the new, severe requirements imposed by modern road traffic. Even if today it is no longer possible to state that motor-vehicle safety depends exclusively on the braking system, the latter undoubtedly represents one of safety's essential factors.

Preventive safety, as far as the motor vehicle is directly concerned, is fundamentally based on vehicle "controllability"; namely, on that complex of characteristics, devices or provisions on which the degree of overall efficiency of the means and systems for controlling speed and direction of travel depends, directly or indirectly. The considerable importance of the rôle the braking system plays in the general picture of motor-vehicle safety is then clearly evident. Furthermore, intensification of research efforts aimed at achieving newer and more challenging objectives in braking development are more than justified.

Among the most interesting devices introduced in the last few years in the braking systems of modern motor-cars, the so called "automatic braking control devices" have marked the beginning of a new era, which will perhaps be characterized by developments even more

sensational than those of the disc brake, in the past decade.

Before illustrating the constructional and functional characteristics of said devices, it is desirable to make some general theoretical considerations on the problem of "braking regulation" in order to obtain a better understanding of the requirements, possibilities and limitations of the different regulation systems at present in use and of those that will presumably find an application in the future.

## BRAKING REGULATION

A vehicle of weight G, braking at deceleration a on a road with slope $\alpha$ with respect to the horizontal (Fig. 1), is considered. With no disturbing actions due to the wind and neglecting drag, under such conditions the vehicle is subjected to the following forces: weight force G, inertia force $G\frac{a}{g}$, normal front and rear forces $N_a$ and $N_p$ and front and rear braking forces $F_a$ and $F_p$.

The equilibrium conditions between said forces are expressed as follows:

$$N_a + N_p = G \cos\alpha \qquad (1)$$

$$F_a + F_p = G\left(\frac{a}{g} \pm \sin\alpha\right) \qquad (2)$$

$$G\left(\frac{a}{g} \pm \sin\alpha\right) h + N_p l = G c \cos\alpha \qquad (3)$$

Indicating by $\mu^*$ the maximum value that the wheel-terrain "coefficient of adhesion" can assume in relation to the particular characteristics of the surfaces in contact, maximum "adhesion" values on front and rear wheels are:

$$A_a^* = \mu^* N_a \qquad (4)$$

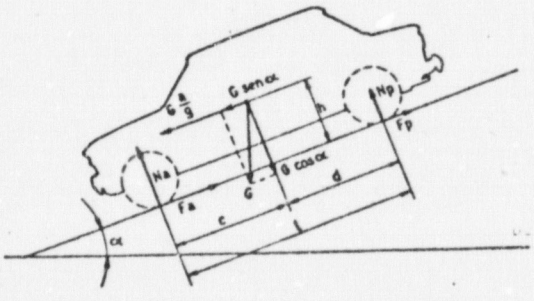


Fig. 1 - Forces acting on vehicle during brake application

$$A_p^* = \mu^* N_p \qquad (5)$$

Introducing maximum "adhesion" values $A_a^*$ and $A_p^*$ in (2), respectively in lieu of braking forces $F_a$ and $F_p$, the maximum or limit theoretical acceleration attainable during braking on an up- or downgrade with inclination $\alpha$, can be expressed as follows:

$$a^* = g\left(\mu^* \cos\alpha \mp \sin\alpha\right) \qquad (6)$$

In the particular case of braking on a level road ($\alpha = 0$) the limit deceleration expression simply becomes:

$$a^* = g\,\mu^* \qquad (7)$$

After having so defined the physical limits of braking deceleration of a motor-vehicle subjected only to force of gravity, force of inertia and retardation forces applied in the wheel-terrain contact area, braking "effectiveness" may be defined as the ratio between mean effective deceleration obtained with maximum braking and theoretical limit deceleration corresponding to the particular adhesion and gradient conditions in which braking occurred:

$$\eta = \frac{a}{a^*} \qquad (8)$$

To obtain maximum braking effectiveness $\eta$, braking forces $F_a$ and $F_p$ acting on motor-vehicle front and rear wheels should therefore be adjusted so as to result, in any moment, exactly equal to the maximum adhesion values $A_a^*$ and $A_p^*$ available:

$$F_a = A_a^* = \mu^* N_a \qquad (9)$$

$$F_p = A_p^* = \mu^* N_p \qquad (10)$$

In spite of their extreme simplicity, these two expressions, that synthetically state the fundamental requirements of motor-vehicle ideal braking regulation, represent one of the most hard-to-solve problems ever met by automotive engineers.

A preliminary examination of the above two formulae might lead to think it necessary, in order to realize an effective braking regulation system, to resort to devices capable of continuously measuring, with sufficient accuracy, the actual values of adhesion coefficient $\mu^*$ and normal load N in the wheel-terrain contact area. In addition, the devices should utilize said information to modulate braking forces F

applied by the driver during maximum braking so as to make them exactly equal to "adhesion" values A*. However, in consideration of the state-of-the art, it does not seem likely that a system based on such an operation principle, even if unobjectionable from a theorical viewpoint, may have any possibility of being adopted. In fact, while measurement of normal wheel loads N and regulation of braking forces F can be carried out without any particular difficulty or excessive complications, measurement of adhesion coefficient $\mu^*$ represents today a practically unsurmountable obstacle as it requires the installation of such complex and delicate equipment as to utterly discourage its use for purposes other than experimental research.

On the other hand, as it will be seen later on, the problem of braking force regulation may have simpler solutions than the one indicated. And even though they cannot be considered a complete and final answer to the problem that for some years has been worrying braking system experts, these solutions have the great merit of being already established, or being about to become accepted as part of modern motor-car braking engineering and of having helped to make a further important step forward on the difficult way to automobile progress and safety.

To better understand how it has been possible to realize the controlling devices in use today and the reasons that justify the present research trends in this field, a graphic representation is given of the conditions that determine "ideal braking", i.e., braking of vehicle front and rear wheels to the adhesion limit.

## IDEAL BRAKING CHARACTERISTIC

Examining again the three braking balance equations and re-writing them for the particular case of ideal braking, i.e., keeping into account $F_a = A_a$ and $F_p = A_p$, simple conversion will give the following:

$$A_a = \frac{G}{l}\left[d + \frac{h}{\cos\alpha}\left(\frac{a}{g} \pm \sin\alpha\right)\right]\left(\frac{a}{g} \pm \sin\alpha\right) \quad (11)$$

$$A_p = \frac{G}{l}\left[c - \frac{h}{\cos\alpha}\left(\frac{a}{g} \pm \sin\alpha\right)\right]\left(\frac{a}{g} \pm \sin\alpha\right) \quad (12)$$

For previously set values of G, l, d, c, h and $\alpha$, i.e., of weight, wheelbase and vehicle center of gravity position, as well as of road gradient, it is possible to calculate front and rear "adhesion" values corresponding to different deceleration a values. Furthermore, the so called "ideal braking characteristic" (Fig. 2) can be plotted on the chart having as abscissae front braking forces $F_a$ and as ordinates rear braking forces $F_p$. Said characteristic indicates how intensity of braking forces $F_a$ and $F_p$ should vary in relation to coefficient of adhesion $\mu$ to obtain ideal braking, i.e. to reach limit condition of adhesion on vehicle front and rear wheels at the same time.

It should be noted that in chart ($F_a$, $F_p$) constant deceleration curves, as evident in (2), are straight lines at 45° with respect to the two axes; their intersection with the "ideal characteristic" gives, for each point of the latter, the corresponding adhesion coefficient value. In fact, it should be remembered that in the case of ideal braking adhesion coefficient is linked to deceleration by expression (6).

The ideal characteristic starts from the origin of axes $F_a$ and $F_p$, extends as a parabolic curve and ends on axis $F_a$ at value $A_a = G\frac{c}{h}\cos\alpha$ of front adhesion, determined by condition $\left(\frac{a}{g} \pm \sin\alpha\right) h = c\cos\alpha$ of annulment of the term between brackets in (12) and consequently of rear adhesion $A_p$. Said condition is nothing but that of vehicle longitudinal overturn limit, characterized by the absence of normal loads $N_p$ on rear wheels and by the beginning of lifting from ground of said wheels.

It should be noted that deceleration corresponding to the origin of the chart is nil only in the case of braking on level terrain. For braking on up-or down-grades said deceleration can be obtained making expression $\left(\frac{a}{g} \pm \sin\alpha\right)$ in (11) and (12) equal to zero.

Thus:

$$a = \begin{cases} -g\sin\alpha \text{ (vehicle travelling downhill)} \\ +g\sin\alpha \text{ (vehicle travelling uphill)} \end{cases} \quad (13)$$

In the first case, in the above specified conditions of no adhesion and therefore with $\mu = 0$, deceleration takes a negative value, i.e., the vehicle descends with uniformly accelerated motion under the motive action of weight force component $G\sin\alpha$ which is balanced by the force of inertia alone.

In the second case the vehicle decelerates uniformly under the only retarding action of the same component $G\sin\alpha$ in equilibrium with the force of inertia.

A practical example will now illustrate

[DX 689, p 302]



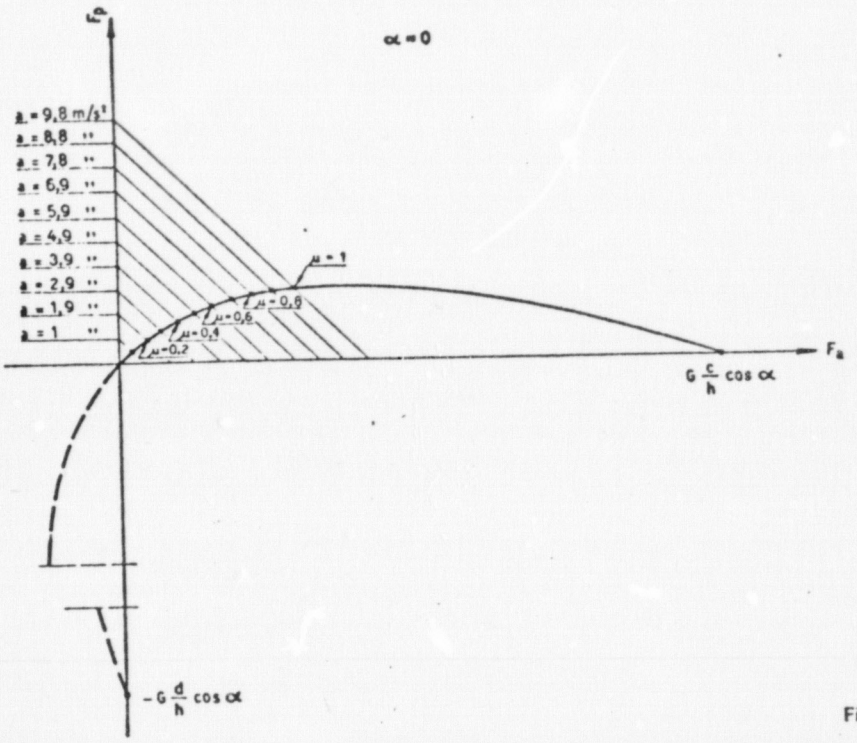


Fig. 2 - Ideal braking characteristic

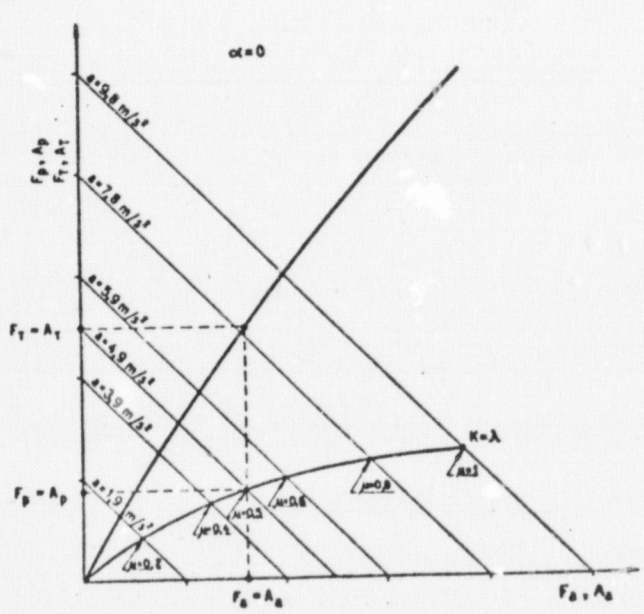


Fig. 3 - Braking forces $F_T$, $F_a$, $F_p$ under ideal braking conditions



[DX 689, p 302]

the procedures for reading and interpreting the ideal braking characteristic chart.

A vehicle has been considered which is equipped with a braking system capable of ensuring, depending on the force applied to brake pedal, apportionment of the total braking force on front and rear wheels exactly in conformance with the ideal characteristic curve. Assuming that wheel-terrain adhesion coefficient is $\mu = 0.5$, then maximum attainable deceleration will be 4,9 $m/s^2$: this is in fact the value corresponding to the constant deceleration curve intersecting the ideal characteristic at the point indicated by value $\mu = 0.5$ of the adhesion coefficient (Fig. 3).

Maximum deceleration $a = 4,9\ m/s^2$ is obtained with total braking force $F_T = A_T$ and braking ratio $\lambda = \frac{F_a}{F_p} = \frac{A_a}{A_p} = K$.

At higher values of braking force $F_T$, front and rear wheels lock simultaneously; this generally determines a decay of available adhesion and, therefore, the acceleration values are lower than maximum.

At lower values of braking force $F_T$, braking forces on front and rear wheels are instead always lower than respective available "adhesion" values $A_a$ and $A_p$; this is the field of partial braking and the deceleration of every single point of useful length of braking ideal characteristic, is that which is associated with the constant deceleration curve crossing the point in question.

COEFFICIENT OF ADHESION

Any precise definition of both nature and properties pertaining to the coefficient of adhesion $\mu$ has so far been avoided in order to attain greater simplicity and clarity in the description of the fundamental aspects of braking dynamics.

The "coefficient of friction" between two surfaces in contact, one sliding on the other, is by definition the ratio between the force that the two surfaces transmit to each other in the direction of sliding and the load acting in the direction normal to the surfaces in the contact area.

As known, said coefficient depends on the nature, condition and sliding velocity of the surfaces in contact.

Similarly, the "coefficient of adhesion" $\mu$, as related to road-tire contact, is defined as the ratio between the force acting on the road surface, in the direction of wheel slip, and the normal load transmitted by the wheel to the road surface.

However, owing to the peculiar nature of road-tire ratio, it is not possible to regard the coefficient of adhesion $\mu$ as endowed with the same variability characteristics of a generic coefficient of friction, unless only the case of locked wheels sliding on the ground is considered, though still with some reservation. Actually, also in the case of a wheel completely or partially free to turn, i.e., before reaching the "locking" condition, single or simultaneous transmission of a longitudinal or transversal force from tire to terrain inevitably involves sliding of one on the other and, consequently, corresponding values of adhesion coefficient $\mu$.

Extensive experimental research work conducted to this end in the last few years, has by now clarified, if not completely at least to a good extent, the influence exercised on the value of coefficient of adhesion $\mu$ by the various factors from which it depends. The qualitative and quantitative research results have proved really valuable for the study and development of the latest automatic braking control devices and represent a sound starting point for further new and interesting developments in this field.

In the light of the latest knowledge the road-tire coefficient of adhesion depends on the following factors :

- Tire characteristics, namely: size, construction, material, tread pattern and wear conditions, inflation pressure and temperature.
- Road characteristics, namely: terrain nature and composition, surface condition (dry, damp, wet, snowy, icy) and temperature.
- Road-tire contact characteristics: normal load transmetted from wheel to terrain, slip velocity, slip direction as referred to wheel advancement theoretical direction.

Therefore, for given tire and road characteristics and for a given normal load N, the adhesion coefficient may be expressed as a function of two parameters only, namely, slip velocity and slip direction.

In the particular case where, owing to the absence of any transverse wheel loading, the direction of slip coincides with wheel advancement direction, which case conforms to the hypothesis normally acknowledged in the theoretical analysis of the problems connected with braking during straight-ahead driving, the adhesion

coefficient to be considered is termed "longitudinal" and will be identified by $\mu_L$ in order not to confuse it with the "transverse" adhesion coefficient $\mu_T$. The formula relating resultant adherence coefficient $\mu_R$ to $\mu_L$ and $\mu_T$ is as follows:

$$\mu_R = \sqrt{\mu_L^2 + \mu_T^2} \qquad (14)$$

Coefficient $\mu_R$ is thus the sum of the two vectors $\bar{\mu}_L$ and $\bar{\mu}_T$ at 90° with respect to each other.

Instead of the absolute slip velocity it is possible to consider separately the two following variables:

- Wheel advancement velocity: V
- Relative slip s

$$s = \frac{V - \omega R_r}{V} \qquad (15)$$

where $\omega$ = Wheel angular velocity, and

$R_r$ = Actual tire rolling radius.

Graphical representation of $\mu_L$ curve in relation to s (see Fig. 4) emphasises the particular road-tire surface adhesion characteristics within the two extremes of "free-wheel" (s=0) and "locked wheel" (s = 1) conditions and leads to some interesting considerations.

To begin with, it may be noted that s=0 means that $\mu_L = 0$ at all times, i.e. any longitudinal force necessarily involves a measure of slip. The longitudinal adhesion coefficient $\mu_L$ increases rapidly after a virtually linear fashion for .05 to .1 relative slip. Any further increase in s involves gradually smaller $\mu_L$ increments until a maximum value $\mu_L^*$ is reached. This maximum normally corresponds to a point somewhere between .1 and .3 (s value), though in some cases it may be reached at much higher relative slip values or in the extreme locked wheel condition. Ignoring this last condition, after reaching its max value the coefficient of adhesion decreases more or less rapidly as s increases. When s = 1 the adhesion coefficient becomes $\mu_{LL}$ or "coefficient of longitudinal adhesion in lock condition".

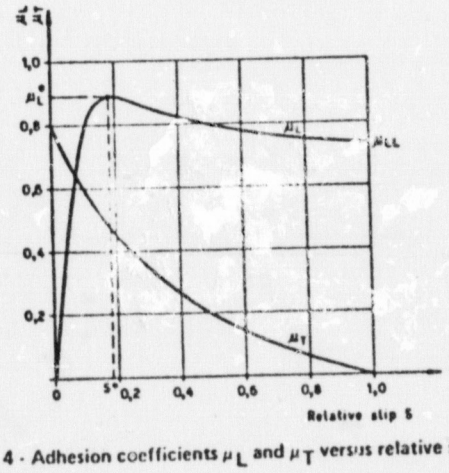


Fig. 4 - Adhesion coefficients $\mu_L$ and $\mu_T$ versus relative slip s

The max value point in ($\mu_L$, s) chart delimitates the stability range of a partially braked wheel. In fact, while within a 0 to s* relative slip range the increase in braking force applied to the wheel may be compensated by a corresponding increase in "adhesion", when the latter has reached its max value $A_L^* = \mu_L^* N$ any further increase in braking force will inevitably and rapidly lead to wheel locking (s = 1).

Ratio $\frac{\mu_L^*}{\mu_{LL}} = \varrho$ between max longitudinal adhesion coefficient and coefficient of longitudinal adhesion in lock condition, may range from 1 to 3 in most cases, the lower values being associated with dry or icy road surfaces and the higher ratios with wet surfaces.

The effect of wheel velocity V on the longitudinal adhesion characteristic $\mu_L = f(s)$ generally occurring as velocity itself increases, takes the form of increasing up-slope in the initial linear section of the curve and pronounced down-slope in the second section, often followed by an increase in $\frac{\mu_L^*}{\mu_{LL}} = \varrho$ ratio.

If both longitudinal and transverse adhesion characteristics, i.e. both $\mu_L = f(s)$ and $\mu_T = f(s)$ curves, are plotted in the same chart, it is immediately evident that, in order to obtain satisfactory conditions in terms of adhesion in either direction, relative slip s should, if possible, be contained within .1 to .3. In this connection it will be noted that these values are the same as those previously indicated for $\mu_L$ max.

In the chart ($\mu_L$, $\mu_T$) (see Fig.5), $\mu_L$ and $\mu_T$ values corresponding to the same relative slip value s are sufficient to plot the resultant adhesion coefficient characteristic $\mu_R$ or wheel adhesion boundary curve, as applicable to the conditions in which $\mu_L$ and $\mu_T$ were determined. The line connecting the chart origin with any point of the above characteristic gives a measure of the resultant adhesion coefficient $\mu_R$ in a direction such as to form angle $\gamma$ with that of the longitudinal adhesion. Curve $\mu_T = f(\mu_L)$ is within an arc of circle termed "friction boundary circle" with its centre in the origin of the axes and radius equal to the absolute max adhesion coefficient.

Points A and C denoting where adhesion boundary curve intersects $\mu_T$ and $\mu_L$ axes represent transverse adhesion coefficient in free-wheel condition $\mu_{TF}$ and longitudinal adhesion coefficient in locked-wheel condition $\mu_{LL}$ respectively. Moreover, point B of max longitudinal adhesion coefficient $\mu_L^*$ splits the curve into two sections AB and BC, the former representing stable and the latter unstable adhesion conditions.

Practical use of typical charts, such as those which have been dealt with up to now in connection with road-tire adhesion coefficient, for the theoretical calculations on vehicle braking involves enormous difficulties, owing to the many variables coming into play and insufficient experimental data.

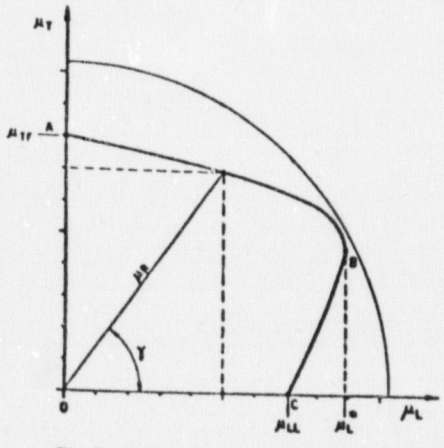


Fig. 5 - Wheel adhesion boundary curve

However, a qualitative appreciation of adhesion coefficient variability characteristics is both indispensable and sufficient to enable the motor vehicle braking regulation problem to be set-out in a rational manner.

## OBJECTIVES OF BRAKING REGULATION

Firstly, it is desirable to focus the main objectives which regulation should achieve. As mentioned in the opening paragraphs, these objectives may be described with one single word: safety. In our specific case safety means: high effectiveness: (shortest possible stopping distance in the various vehicle load and tire adhesion conditions), stability (tendency for the vehicle to stay on course), steerability (possibility on the part of the driver to alter the course of the vehicle during braking).

It is rather difficult to determine any order of priority for the above objectives as, in absolute terms, all three seem to weigh just as heavily from the safety viewpoint.

A braking system potentially able to ensure maximum effectiveness, i.e. able to exploit tire adhesion to the full, as well as good directional control, would in fact be of little use if lack of stability in case of emergency should impair such desirable qualities or cause accidents even more serious than would have resulted from impact with the obstacle which led to braking in the first place. On the other hand, stability and high braking effectiveness alone would not be sufficient to ensure successful-braking, should the distance between vehicle and obstacle be shorter than the minimum stopping distance, when a controlled amount of course alteration would be required during braking. And, finally, good stability and directional control, coupled with mediocre braking effectiveness, could not be substantially beneficial in those fairly frequent cases where stopping distance becomes the deciding factor, owing to the impossibility of altering course because of road or traffic conditions.

However, looking on things with greater objectivity and, above all, trying to decide which of the three objectives could be more conveniently dropped should one of them have to be eliminated, inevitably leads to the following order of priority: stability, steerability, high effectiveness.

It may perhaps seem rather strange that effectiveness takes third place, considering the pre-eminent and fundamental rôle instinctively attributed to it in connection with vehicle braking. On the other hand it should be

remembered that the performance of a non-regulated but correctly balanced, conventional braking system, as fitted to current production cars, is such as to allow little room for improvements in terms of stopping distance in the most frequent conditions of adhesion.

Moreover, as may easily be anticipated and as will be seen later, attainment of either or both of the other two characteristics almost invariably involves an automatic increase in braking effectiveness. Thus, it is logical to consider braking force regulation mainly as a safety requirement for stability and directional control during braking.

As is usually the case when dealing with multifarious targets, after the initial stimulating trials striving for a overall solution, the braking force regulation problem came to be approached more gradually and realistically in recent years by the car engineers concerned.

The remarkable, if partial, results obtained to date are already noticeable on a good and constantly increasing proportion of cars. At this initial stage, according to the previously mentioned order of priority, particular attention was given to stability and, consequently, to braking effectiveness.

On the contrary, the already-implemented second stage will see brake specialists striving for a progressive solution of the directional control problem, and the fall-out generated in the process will enable the other two characteristics (stability and braking effectiveness) to be improved still further.

## REGULATION CRITERIA

After defining braking regulation objectives, it will now be seen where and how braking force regulation works, on the basis of the preliminary theoretical considerations and subsequent qualitative analysis of road-tire adhesion coefficient variability characteristics.

The parameters to be regulated or controlled are obviously the braking forces applied to the road wheel surfaces in contact with the ground. In this connection it should be noted that these forces are not generated only by the brake units themselves. Indeed, they are the resultant of all retardation forces acting on tire periphery, inclusive of rolling resistance, resistance due to friction in the transmission and engine braking torque, in case of live axle wheels. Consequently, owing to the origin of these secondary retardation forces, braking force regulation can be but partial.

In the more typical case of a two-axle vehicle, the following possibilities emerge, in terms of parameters to be regulated:

- Regulation of total front braking force.
- Regulation of total rear braking force.
- Regulation of both front and rear total braking force.
- Regulation of both rear braking forces and total front braking force.
- Regulation of both front braking forces and total rear braking force.
- Regulation of both front braking forces and both rear braking forces.

Before defining any braking regulation procedure it is necessary to throw light on the relationship between wheel braking forces and the foregoing characteristics (stability, steerability and effectiveness).

Both stability and steerability depend on front and rear wheel ability to withstand any transverse load generated during braking without exceeding the associated limits of adhesion. In turn, this ability to withstand transverse loading is subject to the applied wheel braking forces, as clearly evidenced by the resultant adhesion coefficient characteristic $\mu_R$ which for a certain normal and constant load N gives, on a different scale, the limits of transverse force T in relation to braking force F. More particularly, even when braking on a straight road, rear wheel lock can cause a loss of stability should the vehicle be subject to the upsetting effect of a transverse force, whereas front wheel lock prevents any course alteration or correction on the part of the driver.

As regards effectiveness, bearing in mind the definition given in the foregoing and the characteristic curve of longitudinal adhesion coefficient $\mu_L$, minimum stopping distances can be obtained subject to the possibility of controlling wheel braking forces so as to keep relative slip values very close on optimum adhesion: a condition which, as mentioned, usually also meets fundamental stability and steerability requirements.

In conclusion it may be stated that braking regulation requires:

- Rear braking force control for stability and effectiveness.
- Front braking force control for steerability and effectiveness.
- Front and rear braking force control for stability, steerability and effectiveness.

PAGE 317 "AUTOMATIC REGULATION DEVICES" THROUGH PAGE 318



with hydraulic subordination of roller position to rear normal load N, was the first example of semi-automatic brake regulator to be fitted as standard equipment on a mass-production car (Citroën).

## AUTOMATIC REGULATION DEVICES

While semi-automatic regulation devices are now commonly employed, automatic devices, namely those suitable for controlling wheel slip (and consequently, stability, steerability, braking effectiveness and efficiency) without any corrective action by the driver, are still at the experimental stage, even if some of them have already reached a fairly good level of development and sophistication.

The automatic regulator operation principle may be illustrated by the characteristic chart which gives the adhesion coefficient values versus relative slip.

In the case of a braked wheel subject to constant normal load N, said chart corresponds in fact to that of available adhesion moment $M_a$ (Fig. 23). By keeping into account equilibrium expression (17), it is possible to follow and interpret the various stages of regulation cycle through the use of this chart.

Supposing that braking moment $M_f$, increasing from 0 to $M_{f\,MAX}$, is gradually applied to the wheel, until slip value $s_1$, approximately at the knee of characteristic curve $M_a$, is reached, a moderate increase in wheel angular deceleration will occur, since any variation in braking moment $M_f$ is accompanied by an almost equivalent variation in adhesion moment $M_a$ in the same way.

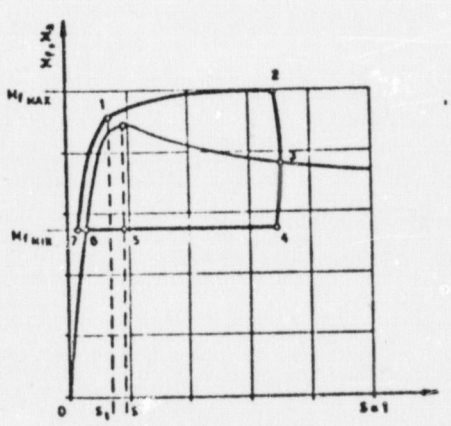


Fig. 23 - Operation cycle of automatic regulation devices

On the contrary, after point 1 has been passed, any further increase in $M_f$ immediately causes wheel instability conditions. These are characteristized by an abrupt increase in wheel angular deceleration as a consequence of the greatly diverging braking moment up-slope and adhesion moment down-slope characteristics.

Wheel lock would therefore occur rapidly and inevitably were it not for automatic regulator cut-in at point 2 which causes a timely reduction of the braking moment at value $M_{f\,MIN}$.

Consequently, in a very short time wheel deceleration passes from maximum value of point 2 to zero value of point 3. Starting from this point the wheel is subjected to an acceleration value that increases up to point 5 and then decreases and becomes nil in point 6.

Section 6-7 is still in a deceleration phase; at point 7 the regulator cuts-in to return the braking moment gradually to $M_{f\,MAX}$.

Thus the cycle is repeated throughout the brake application time with a frequency depending on regulator characteristics and provided a constant effort is maintained on brake control.

The width of relative slip band in which the regulation cycle occurs must be as narrow as possible, as it is on this width that the average adhesion value used depends.

For an ideal regulation the above band should also be normally centered with respect to the value of relative slip $s^*$ corresponding to maximum longitudinal adhesion.

Furthermore, it should be possible to automatically tune to different values depending on instantaneous stability and steerability requirements. Performance of the above cycle, relevant to the regulation of a single wheel, is made possible in practice by the use of the following basic equipment: a sensor, a control unit, an actuator and, possibly, a power unit.

The first picks up the quantities chosen as subordination parameters, the second interprets the information sent by the sensor and transmits the signals to establish the beginning of the different stages of the cycle, the third performs the operations required and, finally, the fourth provides the power that might be needed for said operations.

Going back to what has previously been said on the various degrees of regulation, it is clear that, for a two-axle vehicle, the most complete regulation 0 system must

incorporate at least four sensors and four separate control and actuation units or, in other words, an indipendent regulation device for each single wheel (Fig. 24). Aside from any economic consideration, such a system would not be free from trouble, above all if the regulation devices could not enable the braking force to be adapted to the transient transversal adhesion requirements of each wheel. Braking on terrain with considerably uneven adhesion characteristics could in fact cause dangerous skidding or require a prompt corrective action by the driver on the steering control, as a consequence of the great difference between the braking forces acting on both sides of the vehicle. For said reason, in addition to constructional simplicity and lower cost, solutions providing a lower regulation degree (C, D, E, F) could therefore be preferable. In this case, the feasible variants are those illustrated in diagrams I to VIII (Fig. 24), where the control unit of one or both axles (i.e. two or four wheels) compares the signals from the relevent sensors and selects those of the lower adhesion wheel (select low system) or higher adhesion wheel (select high system) for the conversion into signals to be sent to the actuation unit.

In the different solutions so far investigated the basic equipment is of the following type :

- Sensor: mechanical (generally inertia type) or electromagnetic (pulse generator or tacho-generator).
- Control unit: mechanical, electric, hydraulic or pneumatic.
- Actuator: hydraulic, pneumatic, air-hydraulic or electropneumatic.
- Power unit (if provided): hydraulic (mechanical or electric control) or pneumatic (generally vacuum type).

As to actual braking effectiveness, the tests conducted with automatic regulators have shown that, depending on vehicle initial speed and degree of regulation of the device adopted, it is possible to obtain approximate reductions in stopping distance between 5 and 50% on low adhesion coefficient terrains, and between 3 and 15% on high adhesion coefficient terrains.

A short review will now illustrate some of the most interesting systems among the many proposed since the beginning of research and testing in the field of automatic motor-vehicle braking regulation.

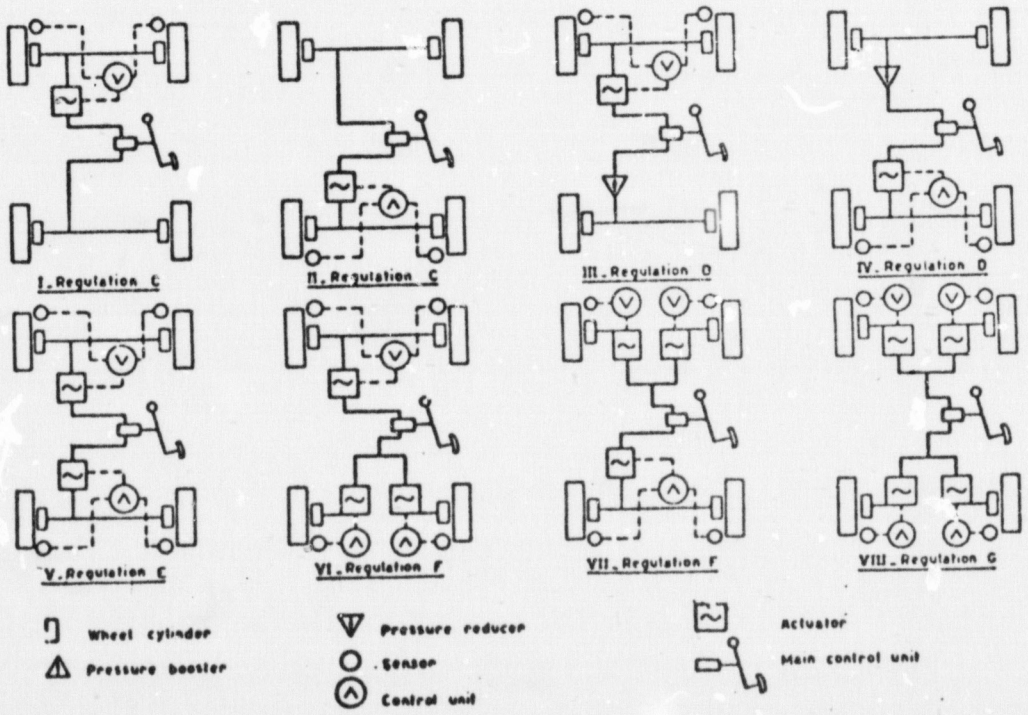


Fig. 24 - Diagrams of brake systems with automatic control devices (degrees C, D, E, F and G)

DEFENDANT'S EXHIBIT 700 (AT 1, 123-24)

Exhibit B
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# CAR BUYING MADE EASIER

1973 Edition

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# SECTION II

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## CHAPTER 12

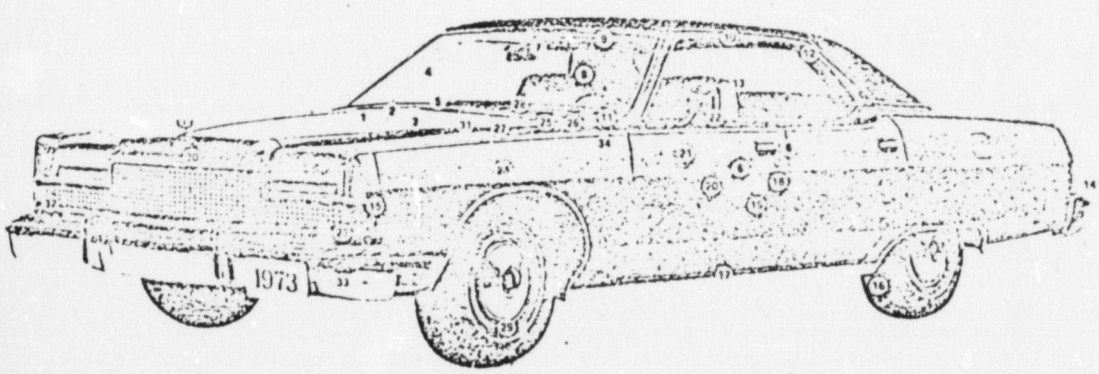
# SAFETY FEATURES

As the illustration below indicates, all 1973 Ford Motor Company cars produced in North America for sale in the United States include a broad range of safety features. Although the automobile pictured is a 1973 Mercury, the Lifeguard Design Safety Features listed are standard equipment on every Ford, Mercury or Lincoln model produced in North America and sold in the U.S.

Items like interior padding, safety-designed knobs and controls, head restraints and shoulder belts increase protection for both the driver and passengers in the event of an impact.

In addition, 1973 models offer improved impact-absorbing laminated safety glass windshields, steel guard rails in side doors, improved front and rear bumpers and a positive reminder warning light and buzzer for front outboard seat belts.

### 1973 FORD MOTOR COMPANY LIFEGUARD DESIGN SAFETY FEATURES




1. Windshield washers.
2. Two-speed or variable speed windshield wipers.
3. Safety glove-box latch (on all cars equipped with glove-boxes).
4. Improved impact absorbing laminated safety glass windshield.
5. Glare reduced instrument panel padding, windshield-wiper arms, steering wheel hub, rearview mirror and mirror mounting, and windshield pillars.
6. Energy-absorbing armrests and safety-designed door handles.
7. Inside yield-away rearview mirror.
8. Head restraints or high back seats for front outboard occupants.
9. Padded sun visors.
10. Shoulder belts for front outboard occupants (except convertibles).
11. Positive reminder warning light and buzzer for front outboard seat belts.
12. Safety-designed coat hooks (except convertibles).
13. Energy-absorbing front seat back tops with padding.
14. Back-up lights.
15. Side marker lights.
16. Dual Hydraulic Brake System with warning light.
17. Corrosion-resistant brake lines.
18. Double-yoke safety door latches and safety hinges.
19. Self-locking front seat backs on two-door vehicles.
20. Steel guard rails in side doors.
21. Front and rear lap belts with mini buckles for all seating positions and retractors for front and rear outboard occupants.
22. Outside rearview mirror, driver's side.
23. Turn indicators with lane-changing signal feature.
24. Energy-absorbing steering column and steering wheel.
25. Uniform transmission shift quadrant (on all cars equipped with automatic transmissions).
26. Non-reversing odometer.
27. Safety-designed radio control knobs and push buttons (on all cars equipped with radios).
28. Energy-absorbing instrument panel with padding for center and outboard passenger.
29. Safety rim wheels and load-rated tires.
30. Safety design front end structure.
31. Hazard warning flasher.
32. Parking lamps coupled with headlamps.
33. Improved front and rear bumpers.
34. Locking steering column with warning buzzer.

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## FORD INNOVATIONS IN SAFETY

Ford Motor Company has contributed many innovations to vehicle safety, both in theoretical concepts and in the practical application of research to safer designs. These improvements were being introduced as far back as 1927 when Ford was the first in the industry to install, as standard equipment, laminated safety glass in the windshields of automobiles. Ford also introduced all-steel bodies in the 1930's and the first optional "safety package" in 1956.

That "package" included features such as factory installed seat belts, energy-absorbing padded instrument panels and sun visors, a "deep-dish" energy-absorbing steering wheel, and special door latches. Major improvements have been made in all of these areas since that time.

New designs incorporated since 1968 include the energy-absorbing steering column, controlled-crush front ends, flush exterior door handles, warning buzzers, shoulder belts, and improvements in instrument-panel controls, defrosters, brakes, lights, anti-theft devices and other items.

### "Sure-Track," An Innovation In Braking

Ford Motor Company pioneered the first United States passenger-car application of a skid-resistant braking system in 1968. Trade-named "Sure-Track," it consists of a system of sensors, valves, actuator, and an electronic control module all working together to inhibit brake lock-up on wet surfaces, thereby helping to prevent skidding and loss of control of the vehicle. In effect, "Sure-Track" pumps the brakes far more rapidly than a driver could; it releases the brakes just before lock-up would occur and then re-applies them. The control module consists of 160 solid-state components mounted on a printed circuit board inside a plastic container and filled with a rubber-like padding compound. The components include transistors, diodes, capacitors and resistors. Located near the glove box of the vehicle, this system self-adapts for changes in road surface friction and it works through just about maximum speed down to approximately five miles per hour.

### Tot Guard:
### An Important Contribution To Child Safety

In 1957 Ford became the first auto manufacturer to offer a child restraint device in the form of a small vest attached to seat belts. In 1965 the Astro-guard child safety seat was marketed. For improved safety while riding, Ford announced development of the Tot-Guard Child Safety Seat in 1967. This unit spans the child's body, cradling it for better protection in collision impacts. Tot-Guard has been commended by independent safety experts as the best on the market for children weighing up to 50 pounds.

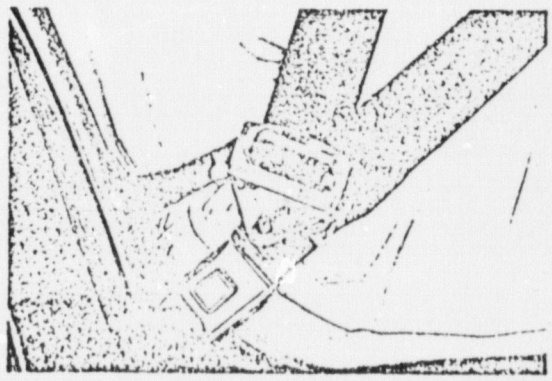
## WHY "BUCKLE UP"?

Mr. Douglas Toms, former Administrator of the National Highway Traffic Safety Administration, has stated that he knows of no instance in which anyone wearing both lap and shoulder belts has been killed in an accident at speeds up to 50 miles per hour while driving a car manufactured since 1958. In a recent study of 160 accident cases, in which 60% of the vehicles had heavy damage of the type often associated with occupant injury, 99% of the lap-shoulder belt users had no injury or only minor injury.

These statistics, along with many others, point to the importance of seat and shoulder belts in prevent-

### A BETTER IDEA FOR SAFETY: "UNI-LOCK" MAKES SAFETY BELTS EASIER TO USE

All 1973 Ford Motor Company cars (except convertible models) feature this Better Idea safety belt system, "Uni-Lock," for both the driver and outboard front-seat passenger. With "Uni-Lock," the lap belt and the shoulder belt can be connected, adjusted and then left locked together so that both belts will buckle as a single unit for the same person each time, yet will retract when not in use.



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NO MATERIAL ON PAGE E-1286

DEFENDANT'S EXHIBIT 708
(COVER, PAGES 1, 13, 15, 22, 27, 31, 34, 35, 40, 44)

## Simulation of Perma Anti-Skid Device

Threshold .92g
Pressure Switch Setting:

| | Opens | Closes |
|---|---|---|
| in footpounds | 150 | 250 |
| in psi (approximately) | 115 | 159 |

Gear Ratio 18:1

| Surface Coefficient of Friction | MPH Speed | With Distance in Feet | | Without Distance in Feet |
|---|---|---|---|---|
| .75 | 60 | 157.7 (1) | I (green) | 160.8 (3) |
| | 25 | 29.8 (5) | II (black, red) | 29.3 (6) |
| .7 | 60 | 166.9 (7) | | 171.2 (9) |
| | 40 | 77.5 (11) | | 77.9 (12) |
| | 25 | 31.5 (13) | I (green) | 31.2 (14) |
| .5 | 60 | 174.1 (15) | I (green) | 188.2 (16) |
| | 25 | 29.3 (17) | | 29.1 (18) |
| .2 | 35 | 167.4 (21) | II (black, red, green) | 195.6 (23) |
| | 25 | 83.3 (22) | II (yellow) | 101.4 (25) |
| | 15 | 32.8 (31) | I (green) | 36.8 (33) |
| .15 | 25 | 122.9 (34) | II (yellow, green) | 134.6 (37) |
| | 20 | 78.0 (41) | I (green) | 86.8 (43) |
| | 15 | 43.6 (44) | I (green) | 49.1 (45) |

O ⇒ page 44

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id: 4/4/29

[DX 708, p 1]

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.0 | 90.00 | 0.00 | 0.0 | 88.00 | 0.00 | 0.000 | 88.00 | 0.00 | 0.000 | 0.0 | 88.00 | 0.00 | 0.000 | 88.00 | 0.00 | 0.000 | | |
| 0.050 | 4.4 | 87.60 | 0.37 | 645.6 | 84.06 | -3.03 | 0.041 | 84.06 | -3.03 | 0.041 | 308.2 | 85.14 | -2.20 | 0.029 | 85.14 | -2.20 | 0.029 | | |
| 0.100 | 8.8 | 85.87 | 0.61 | 1150.4 | 76.55 | -3.98 | 0.056 | 78.55 | -3.98 | 0.056 | 512.2 | 82.60 | -1.45 | 0.049 | 82.60 | -1.45 | 0.049 | | |
| 0.150 | 13.1 | 85.78 | 0.71 | 1582.9 | 68.90 | -9.02 | 0.198 | 68.90 | -9.02 | 0.198 | 602.2 | 79.99 | -1.80 | 0.068 | 79.99 | -1.80 | 0.068 | | |
| 0.200 | 17.3 | 84.61 | 0.74 | 1876.3 | 46.49 | -17.53 | 0.450 | 45.49 | -17.53 | 0.450 | 655.9 | 76.75 | -2.27 | 0.093 | 76.75 | -2.27 | 0.093 | | |
| 0.250 | 21.5 | 83.37 | 0.76 | 2140.5 | 13.40 | -23.36 | 0.839 | 13.40 | -23.36 | 0.839 | 717.3 | 72.38 | -3.35 | 0.133 | 72.38 | -3.35 | 0.133 | | |
| 0.300 | 25.7 | 82.16 | 0.77 | 2330.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 756.6 | 64.87 | -6.04 | 0.211 | 64.87 | -6.04 | 0.211 | | |
| 0.350 | 29.8 | 80.92 | 0.78 | 2478.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 787.1 | 53.35 | -8.16 | 0.341 | 53.35 | -8.16 | 0.341 | | |
| 0.400 | 33.8 | 79.65 | 0.80 | 2594.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 810.9 | 39.03 | -9.53 | 0.510 | 39.03 | -9.53 | 0.510 | | |
| 0.450 | 37.7 | 78.35 | 0.82 | 2683.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 829.5 | 23.03 | -10.27 | 0.706 | 23.03 | -10.27 | 0.706 | | |
| 0.500 | 41.6 | 77.02 | 0.84 | 2339.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 759.4 | 6.54 | -8.10 | 0.915 | 6.54 | -8.10 | 0.915 | | |
| 0.550 | 45.4 | 75.65 | 0.83 | 442.0 | 28.66 | 37.66 | 0.621 | 28.66 | 37.66 | 0.621 | 265.2 | 5.97 | 6.51 | 0.921 | 5.97 | 6.51 | 0.921 | | |
| 0.600 | 49.2 | 74.33 | 0.79 | 1765.4 | 60.03 | -7.50 | 0.085 | 66.03 | -7.50 | 0.085 | 639.9 | 13.37 | -3.35 | 0.620 | 13.37 | -3.35 | 0.620 | | |
| 0.650 | 52.8 | 72.88 | 0.80 | 1089.0 | 63.81 | 19.78 | 0.125 | 63.81 | 19.78 | 0.125 | 500.3 | 7.32 | 1.22 | 0.900 | 7.32 | 1.22 | 0.900 | | |
| 0.700 | 56.5 | 71.72 | 0.77 | 1607.7 | 66.21 | -8.53 | 0.085 | 66.21 | -8.53 | 0.085 | 623.9 | 13.13 | -0.87 | 0.817 | 13.13 | -0.87 | 0.817 | | |
| 0.750 | 60.0 | 70.42 | 0.80 | 1504.7 | 47.92 | 5.04 | 0.321 | 47.92 | 5.04 | 0.321 | 586.1 | 8.55 | 0.86 | 0.879 | 8.55 | 0.86 | 0.879 | | |
| 0.800 | 63.5 | 69.03 | 0.80 | 2074.6 | 58.31 | -12.32 | 0.156 | 50.31 | -12.32 | 0.156 | 703.7 | 11.30 | -1.90 | 0.826 | 11.30 | -1.90 | 0.936 | | |
| 0.850 | 66.9 | 67.69 | 0.05 | 1390.4 | 47.64 | 4.30 | 0.296 | 47.64 | 4.30 | 0.296 | 564.1 | 10.63 | 2.11 | 0.843 | 10.63 | 2.11 | 0.843 | | |
| 0.900 | 70.3 | 66.36 | 0.80 | 1950.0 | 32.63 | -14.47 | 0.508 | 32.63 | -14.47 | 0.508 | 678.0 | 9.66 | -1.83 | 0.851 | 9.66 | -1.83 | 0.851 | | |
| 0.950 | 73.6 | 65.09 | 0.77 | 1621.7 | 22.33 | -13.08 | 0.657 | 22.33 | -13.08 | 0.657 | 651.5 | 10.50 | -0.93 | 0.839 | 10.50 | -0.93 | 0.839 | | |
| 1.000 | 76.8 | 63.97 | 0.73 | 1445.6 | 3.75 | -4.96 | 0.941 | 3.75 | -4.96 | 0.941 | 573.9 | 9.65 | 0.92 | 0.849 | 9.65 | 0.92 | 0.849 | | |
| 1.050 | 80.0 | 62.73 | 0.71 | 1070.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 610.1 | 10.18 | -0.34 | 0.8 | 10.18 | -0.34 | 0.838 | | |
| 1.100 | 83.1 | 61.59 | 0.71 | 1103.3 | 0.56 | 1.51 | 0.991 | 0.56 | 1.51 | 0.991 | 519.7 | 10.47 | 2.10 | 0.830 | 10.47 | 2.10 | 0.830 | | |
| 1.150 | 86.1 | 60.45 | 0.71 | 1684.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 623.2 | 9.75 | -0.96 | 0.839 | 9.75 | -0.96 | 0.839 | | |
| 1.200 | 89.1 | 59.31 | 0.72 | 1702.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 627.0 | 10.57 | -1.04 | 0.822 | 10.57 | -1.04 | 0.822 | | |
| 1.250 | 92.0 | 58.15 | 0.73 | 1629.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 611.9 | 9.58 | -0.62 | 0.835 | 9.58 | -0.62 | 0.835 | | |
| 1.300 | 94.9 | 56.96 | 0.74 | 1670.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 621.9 | 10.35 | -0.82 | 0.818 | 10.35 | -0.82 | 0.818 | | |
| 1.350 | 97.7 | 55.75 | 0.76 | 1230.6 | 0.70 | 4.69 | 0.991 | 0.50 | 4.69 | 0.991 | 529.5 | 9.83 | 1.03 | 0.824 | 9.83 | 1.03 | 0.824 | | |
| 1.400 | 100.5 | 54.50 | 0.78 | 1658.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 617.8 | 10.07 | -0.68 | 0.815 | 10.07 | -0.68 | 0.815 | | |
| 1.450 | 103.2 | 53.23 | 0.01 | 1404.5 | 5.16 | 3.45 | 0.963 | 5.16 | 3.45 | 0.902 | 565.4 | 10.74 | 0.83 | 0.798 | 10.74 | 0.83 | 0.798 | | |
| 1.500 | 105.8 | 51.92 | 0.81 | 1681.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 632.5 | 9.60 | -0.95 | 0.815 | 9.60 | -0.95 | 0.815 | | |
| 1.550 | 108.4 | 50.58 | 0.84 | 1714.0 | 7.66 | -2.54 | 0.849 | 7.66 | -2.54 | 0.849 | 620.3 | 10.44 | -1.19 | 0.794 | 10.44 | -1.19 | 0.794 | | |
| 1.600 | 110.9 | 49.22 | 0.86 | 1379.2 | 9.64 | 8.19 | 0.804 | 9.64 | 8.19 | 0.804 | 560.2 | 9.46 | 0.60 | 0.838 | 9.46 | 0.60 | 0.838 | | |
| 1.650 | 113.3 | 47.79 | 0.90 | 1528.8 | 24.34 | 7.42 | 0.491 | 24.34 | 7.42 | 0.491 | 591.1 | 9.96 | -0.45 | 0.792 | 9.96 | -0.45 | 0.792 | | |
| 1.700 | 115.6 | 46.32 | 0.80 | 1673.1 | 42.39 | 13.65 | 0.085 | 42.39 | 13.65 | 0.085 | 497.0 | 9.79 | 1.95 | 0.789 | 9.79 | 1.95 | 0.789 | | |
| 1.750 | 117.9 | 45.12 | 0.77 | 1479.2 | 41.57 | -0.48 | 0.079 | 41.57 | -0.48 | 0.079 | 510.0 | 9.94 | -0.20 | 0.780 | 9.94 | -0.20 | 0.780 | | |
| 1.800 | 120.2 | 43.91 | 0.65 | 1209.6 | 41.44 | -2.24 | 0.057 | 41.44 | -2.24 | 0.057 | 525.2 | 10.60 | 1.72 | 0.793 | 10.60 | 1.72 | 0.793 | | |
| 1.850 | 122.3 | 42.61 | 0.86 | 1724.0 | 37.93 | -1.42 | 0.110 | 37.93 | -1.42 | 0.110 | 631.3 | 9.65 | -1.17 | 0.773 | 9.66 | -1.17 | 0.773 | | |
| 1.900 | 124.4 | 41.38 | 0.04 | 1728.5 | 37.03 | -3.79 | 0.106 | 37.03 | -3.79 | 0.106 | 632.3 | 10.03 | -0.80 | 0.738 | 10.03 | -0.80 | 0.738 | | |
| 1.950 | 126.5 | 39.99 | 0.82 | 1337.9 | 35.73 | -6.37 | 0.107 | 35.73 | -6.37 | 0.107 | 551.7 | 9.61 | 1.44 | 0.760 | 9.61 | 1.44 | 0.760 | | |
| 2.000 | 128.4 | 38.71 | 0.86 | 1783.1 | 32.48 | -3.62 | 0.161 | 32.48 | -3.62 | 0.161 | 643.6 | 10.26 | -1.02 | 0.735 | 10.26 | -1.02 | 0.735 | | |
| 2.050 | 130.3 | 37.33 | 0.73 | 1302.1 | 34.25 | -1.08 | 0.084 | 34.25 | -1.08 | 0.084 | 560.8 | 10.70 | 1.29 | 0.714 | 10.70 | 1.29 | 0.714 | | |
| 2.100 | 132.2 | 36.05 | 0.83 | 1736.6 | 30.91 | -3.84 | 0.193 | 26.91 | -3.84 | 0.193 | 634.0 | 9.60 | -1.08 | 0.731 | 9.63 | -1.08 | 0.731 | | |
| 2.150 | 133.9 | 34.78 | 0.83 | 1743.7 | 30.30 | -4.44 | 0.129 | 30.30 | -4.44 | 0.129 | 636.4 | 10.59 | -1.00 | 0.695 | 10.59 | -1.08 | 0.695 | | |
| 2.200 | 135.6 | 33.44 | 0.83 | 1420.8 | 29.00 | 5.52 | 0.133 | 29.00 | 5.52 | 0.133 | 568.8 | 9.44 | 0.50 | 0.718 | 9.44 | 0.50 | 0.718 | | |
| 2.250 | 137.3 | 32.21 | 0.85 | 1460.7 | 27.83 | -0.65 | 0.136 | 27.83 | -0.65 | 0.136 | 619.9 | 10.29 | -0.75 | 0.680 | 10.29 | -0.75 | 0.680 | | |
| 2.300 | 138.9 | 30.71 | 0.84 | 1003.6 | 29.04 | -0.05 | 0.060 | 29.04 | -0.05 | 0.060 | 501.2 | 10.30 | 2.67 | 0.667 | 10.30 | 2.67 | 0.667 | | |
| 2.350 | 140.4 | 29.62 | 0.88 | 1341.3 | 24.32 | -3.05 | 0.178 | 24.32 | -3.05 | 0.178 | 655.6 | 9.65 | -1.74 | 0.674 | 9.65 | -1.74 | 0.674 | | |
| 2.400 | 141.8 | 28.38 | 0.83 | 1692.5 | 25.58 | -3.21 | 0.096 | 25.58 | -3.21 | 0.096 | 634.9 | 11.19 | -0.41 | 0.606 | 11.19 | -0.41 | 0.606 | | |
| 2.450 | 143.2 | 26.95 | 0.75 | 1259.7 | 24.80 | 3.95 | 0.075 | 24.68 | 3.95 | 0.075 | 535.5 | 9.40 | 1.83 | 0.649 | 9.48 | 1.83 | 0.649 | | |
| 2.500 | 144.5 | 25.69 | 0.54 | 2021.6 | 21.83 | -3.92 | 0.150 | 21.83 | -3.92 | 0.150 | 692.8 | 10.36 | -2.28 | 0.597 | 10.36 | -2.28 | 0.597 | | |
| 2.550 | 145.8 | 24.38 | 0.76 | 1492.6 | 22.63 | -2.89 | 0.071 | 22.63 | -2.89 | 0.071 | 593.6 | 11.22 | 1.17 | 0.540 | 11.22 | 1.17 | 0.540 | | |
| 2.600 | 147.0 | 22.90 | 0.65 | 1507.1 | 19.91 | 9.42 | 0.130 | 19.91 | 9.42 | 0.130 | 603.1 | 9.28 | 0.22 | 0.595 | 9.28 | 0.22 | 0.595 | | |
| 2.650 | 148.1 | 21.62 | 0.86 | 2040.2 | 10.81 | -3.44 | 0.130 | 16.01 | -3.44 | 0.130 | 698.3 | 10.99 | -1.89 | 0.491 | 10.99 | -1.89 | 0.491 | | |
| 2.700 | 149.1 | 20.21 | 0.70 | 1239.6 | 19.04 | -1.84 | 0.058 | 19.04 | -1.84 | 0.058 | 541.7 | 10.90 | 2.65 | 0.461 | 10.90 | 2.65 | 0.461 | | |
| 2.750 | 150.1 | 18.76 | 0.94 | 1877.6 | 13.45 | 0.38 | 0.283 | 13.45 | 0.38 | 0.283 | 665.1 | 9.43 | -1.18 | 0.497 | 9.43 | -1.18 | 0.497 | | |
| 2.800 | 151.0 | 17.42 | 0.94 | 1936.3 | 15.35 | -2.60 | 0.119 | 15.35 | -2.60 | 0.119 | 675.2 | 11.34 | -0.83 | 0.348 | 11.34 | -0.83 | 0.348 | | |
| 2.850 | 151.8 | 15.93 | 0.91 | 1364.6 | 14.61 | -4.54 | 0.083 | 14.61 | -4.54 | 0.083 | 557.2 | 10.19 | 2.19 | 0.360 | 10.19 | 2.19 | 0.360 | | |
| 2.900 | 152.6 | 14.51 | 0.94 | 1991.9 | 12.25 | -3.74 | 0.156 | 12.25 | -3.74 | 0.156 | 686.7 | 10.30 | -1.37 | 0.289 | 10.30 | -1.37 | 0.289 | | |
| 2.950 | 153.3 | 13.12 | 0.90 | 1811.6 | 11.61 | -4.[illegible] | 0.115 | 11.61 | -2.26 | 0.115 | 649.4 | 11.23 | 3.17 | 0.143 | 11.23 | 0.17 | 0.143 | | |
| 3.000 | 153.9 | 11.73 | 0.78 | 1607.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 607.4 | 9.07 | | | | | | | |

1

60 mph, .75 in

[DX 708, p 1]

E-1288

[DX 708, p 13]

3000. 5.33 7.87 18.00 98.65 .030 .020 .030 0.51 0.39 250.0 150.0 0.92 700. .344 20.0

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.0 | 36.67 | 0.01 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | 25 mph | |
| 0.050 | 1.8 | 36.36 | 0.37 | 663.6 | 34.86 | -1.38 | 0.041 | 34.86 | -1.38 | 0.041 | 519.2 | 35.25 | -1.13 | 0.031 | 35.25 | -1.13 | 0.031 | | |
| 0.100 | 3.6 | 35.56 | 0.61 | 1180.4 | 32.32 | -1.83 | 0.091 | 32.32 | -1.83 | 0.091 | 602.2 | 33.87 | -0.92 | 0.048 | 33.87 | -0.92 | 0.048 | 7 m/s | |
| 0.150 | 5.4 | 34.46 | 0.72 | 1582.9 | 27.26 | -6.64 | 0.209 | 27.26 | -6.64 | 0.209 | 602.2 | 32.20 | -1.13 | 0.066 | 32.20 | -1.13 | 0.066 | | |
| 0.200 | 7.1 | 33.30 | 0.70 | 1396.3 | 7.15 | -18.94 | 0.785 | 7.15 | -18.94 | 0.785 | 666.9 | 30.25 | -1.31 | 0.092 | 30.25 | -1.31 | 0.092 | | |
| 0.250 | 8.7 | 32.17 | 0.71 | 2140.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 717.3 | 27.78 | -1.99 | 0.138 | 27.78 | -1.99 | 0.138 | | |
| 0.300 | 10.3 | 31.03 | 0.71 | 2330.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 756.6 | 22.09 | -5.20 | 0.290 | 22.09 | -5.20 | 0.290 | | |
| 0.350 | 11.8 | 29.38 | 0.71 | 2478.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 787.1 | 11.21 | -8.27 | 0.626 | 11.21 | -8.27 | 0.626 | | |
| 0.400 | 13.3 | 28.72 | 0.78 | 657.2 | 10.48 | 26.99 | 0.635 | 10.48 | 26.99 | 0.635 | 394.3 | 5.22 | 1.98 | 0.819 | 5.22 | 1.98 | 0.819 | | |
| 0.450 | 14.7 | 27.90 | 0.63 | 1251.7 | 26.30 | -3.20 | 0.056 | 26.30 | -3.20 | 0.056 | 533.9 | 14.58 | 0.11 | 0.478 | 14.58 | 0.11 | 0.478 | | |
| 0.500 | 16.1 | 26.53 | 0.87 | 1870.5 | 16.28 | -2.03 | 0.386 | 16.28 | -2.03 | 0.386 | 661.6 | 8.05 | -4.11 | 0.697 | 8.05 | -4.11 | 0.697 | | |
| 0.550 | 17.3 | 25.54 | 0.39 | 516.5 | 25.05 | -1.48 | 0.019 | 25.05 | -1 48 | 0.019 | 309.9 | 12.42 | 7.55 | 0.513 | 12.42 | 7.55 | 0.513 | | |
| 0.600 | 18.6 | 24.28 | 0.91 | 2382.5 | 15.87 | -16.30 | 0.347 | 15.87 | -16.30 | 0.347 | 767.3 | 11.36 | -4.75 | 0.532 | 11.36 | -4.75 | 0.532 | | |
| 0.650 | 19.8 | 22.90 | 0.92 | 877.9 | 16.93 | 26.87 | 0.261 | 16.93 | 26.87 | 0.261 | 456.7 | 10.64 | 4.72 | 0.535 | 10.64 | 4.72 | 0.535 | | |
| 0.700 | 20.9 | 21.52 | 0.86 | 2205.0 | 9.79 | -17.75 | 0.546 | 9.79 | -17.7 | 0.546 | 743.0 | 10.26 | -3.07 | 0.522 | 10.26 | -3.07 | 0.522 | | |
| 0.750 | 21.9 | 20.19 | 0.85 | 1767.5 | 9.49 | -4.85 | 0.531 | 9.49 | -4.85 | 0.531 | 640.3 | 12.41 | 0.68 | 0.384 | 12.41 | 0.68 | 0.384 | | |
| 0.800 | 22.9 | 18.93 | 0.75 | 1700.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 626.5 | 9.41 | 0.54 | 0.502 | 9.41 | 0.54 | 0.502 | | |
| 0.850 | 23.8 | 17.72 | 0.74 | 2283.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 746.8 | 12.23 | -2.06 | 0.309 | 12.23 | -2.06 | 0.309 | | |
| 0.900 | 24.7 | 16.54 | 0.72 | 1107.4 | 0.32 | 4.48 | 0.981 | 0.32 | 4.48 | 0.981 | 504.1 | 10.46 | 4.48 | 0.367 | 10.46 | 4.48 | 0.367 | | |
| 0.950 | 25.5 | 15.39 | 0.71 | 2516.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 794.9 | 11.69 | -3.44 | 0.240 | 11.68 | -3.44 | 0.240 | | |
| 1.000 | 26.2 | 14.26 | 0.70 | 1088.4 | 0.33 | 3.18 | 0.977 | 0.33 | 3.18 | 0.977 | 500.2 | 9.81 | 4.56 | 0.311 | 9.81 | 4.56 | 0.311 | | |
| 1.050 | 26.9 | 13.13 | 0.65 | 2470.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 785.4 | 10.34 | -3.25 | 0.212 | 10.34 | -3.25 | 0.212 | | |
| 1.100 | 27.5 | 12.03 | 0.65 | 1618.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 609.7 | 10.96 | -1.15 | 0.089 | 10.96 | -1.15 | 0.089 | | |
| 1.150 | 28.1 | 10.94 | 0.69 | 1875.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 662.7 | 9.67 | -0.43 | 0.116 | 9.67 | -0.43 | 0.116 | | |
| 1.200 | 28.6 | 9.87 | 0.66 | 1416.2 | [illegible] | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 567.8 | 9.03 | -0.24 | 0.086 | 9.03 | -0.24 | 0.086 | | |
| 1.250 | 29.1 | 8.85 | 0.52 | 940.4 | 8.34 | -0.05 | 0.057 | 8.34 | -0.05 | 0.057 | 459.6 | 8.30 | -0.31 | 0.063 | 8.30 | -0.31 | 0.063 | | |
| 1.300 | 29.5 | 8.29 | 0.32 | 532.8 | 8.06 | -0.19 | 0.028 | 8.0[illegible] | -0.19 | 0.028 | 319.7 | 7.99 | -0.16 | 0.037 | 7.99 | -0.16 | 0.037 | | |
| 1.350 | 29.9 | 8.00 | 0.13 | 226.7 | 7.92 | -0.11 | 0.011 | 7.92 | -0.11 | 0.011 | 136.0 | 7.88 | -0.11 | 0.013 | 7.88 | -0.11 | 0.013 | | |
| 1.400 | 30.3 | 7.67 | 0.51 | 949.2 | 7.28 | -1.09 | 0.052 | 7.28 | -1.09 | 0.052 | 471.4 | 7.30 | -0.67 | 0.046 | 7.30 | -0.67 | 0.046 | | |
| 1.450 | 30.7 | 6.50 | 0.75 | 2350.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 760.7 | 5.93 | -0.03 | 0.087 | 5.93 | -0.83 | 0.087 | | |
| 1.500 | 31.0 | 5.25 | 0.79 | 2068.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 867.5 | 4.62 | -0.79 | 0.120 | 4.6[illegible] | -0.79 | 0.120 | | |
| 1.550 | 31.[illegible] | 3.97 | 0.79 | 2440.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 779.3 | 3.27 | 1.03 | 0.180 | 3.2[illegible] | 1.03 | 0.180 | | |
| 1.600 | 31.[illegible] | 2.76 | 0.77 | 2378.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 766.5 | 2.43 | -0.83 | 0.124 | 2.43 | -0.83 | 0.124 | | |
| 1.650 | 31.5 | 1.57 | 0.72 | 1237.5 | 0.09 | 3.13 | 0.940 | 0.09 | 3.13 | 0.940 | 530.9 | 0.07 | 1.10 | 0.959 | 0.07 | 1.10 | 0.959 | | |

[DX 708, p 13]

E-1289

13

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3000. | 5.33 | 7.87 | 18.00 | 58.65 | .030 | .020 | .030 | 0.51 | 0.34 | 250.0 | 150.0 | 0.92 | 700. | .344 | 20.0 | | | | | |
| 0.000 | 0.0 | 88.00 | 0.0 | 0.0 | 88.00 | 0.00 | 0.000 | 88.00 | | 0.00 | 0.000 | | 0.0 | 88.00 | | 0.00 | 0.000 | 88.00 | 0.00 | 0.000 |
| 0.050 | 4.4 | 87.69 | 0.27 | 663.6 | 83.77 | -3.31 | 0.045 | 83.77 | | -3.31 | 0.045 | | 398.2 | 84.96 | | -2.45 | 0.031 | 84.96 | -2.45 | 0.031 |
| 0.100 | 8.8 | 86.89 | 0.60 | 1160.4 | 77.57 | -4.71 | 0.107 | 77.57 | | -4.71 | 0.107 | | 519.2 | 82.21 | | -1.54 | 0.054 | 82.21 | -1.54 | 0.056 |
| 0.150 | 13.1 | 85.85 | 0.66 | 1582.9 | 64.27 | -13.57 | 0.251 | 64.27 | | -13.57 | 0.251 | | 602.2 | 79.47 | | -1.87 | 0.074 | 79.47 | -1.87 | 0.074 |
| 0.200 | 17.3 | 84.79 | 0.64 | 1096.3 | 33.09 | -25.30 | 0.610 | 33.09 | | -25.30 | 0.610 | | 666.9 | 76.12 | | -2.34 | 0.102 | 76.12 | -2.34 | 0.102 |
| 0.250 | 21.6 | 83.80 | 0.60 | 2140.5 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 717.3 | 71.61 | | -3.51 | 0.146 | 71.61 | -3.51 | 0.146 |
| 0.300 | 25.7 | 82.83 | 0.60 | 2330.6 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 756.6 | 63.82 | | -6.11 | 0.230 | 63.82 | -6.11 | 0.230 |
| 0.350 | 29.8 | 81.36 | 0.61 | 2478.7 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 787.1 | 52.25 | | -8.18 | 0.362 | 52.25 | -8.18 | 0.362 |
| 0.400 | 33.9 | 80.89 | 0.61 | 2594.0 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 810.9 | 37.75 | | -9.78 | 0.534 | 37.75 | -9.78 | 0.534 |
| 0.450 | 37.9 | 79.90 | 0.62 | 2683.8 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 829.5 | 20.95 | | -11.07 | 0.738 | 20.95 | -11.07 | 0.738 |
| 0.500 | 41.9 | 78.91 | 0.61 | 1718.9 | 0.0 | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | | 630.3 | 3.73 | | -6.12 | 0.953 | 3.73 | -6.12 | 0.953 |
| 0.550 | 45.8 | 77.89 | 0.68 | 324.6 | 18.60 | 27.30 | 0.761 | 18.60 | | 27.30 | 0.761 | | 134.8 | 4.33 | | 6.98 | 0.944 | 4.33 | 6.98 | 0.944 |
| 0.600 | 49.7 | 76.67 | 0.82 | 1535.0 | 61.99 | 1.93 | 0.192 | 61.99 | | 1.93 | 0.192 | | 592.4 | 13.73 | | -3.14 | 0.821 | 13.73 | -3.14 | 0.821 |
| 0.650 | 53.5 | 75.39 | 0.78 | 1675.7 | 50.46 | 12.47 | 0.331 | 50.46 | | 12.47 | 0.331 | | 497.5 | 5.94 | | -0.71 | 0.921 | 5.94 | -0.71 | 0.921 |
| 0.700 | 57.2 | 74.41 | 0.43 | 817.5 | 72.27 | -7.55 | 0.029 | 72.27 | | -7.55 | 0.029 | | 444.3 | 13.33 | | 1.94 | 0.821 | 13.33 | 1.94 | 0.821 |
| 0.750 | 60.9 | 73.25 | 0.77 | 1676.0 | 51.37 | -6.18 | 0.299 | 51.37 | | -6.10 | 0.299 | | 621.4 | 7.41 | | -3.29 | 0.899 | 7.41 | -3.29 | 0.899 |
| 0.800 | 64.6 | 72.15 | 0.40 | 493.1 | 70.34 | -0.80 | 0.025 | 70.34 | | -0.80 | 0.025 | | 294.1 | 12.20 | | 6.76 | 0.831 | 12.20 | 6.76 | 0.831 |
| 0.850 | 68.1 | 71.07 | 0.74 | 1978.9 | 47.44 | -17.75 | 0.333 | 47.44 | | -17.75 | 0.333 | | 694.0 | 8.24 | | -4.60 | 0.884 | 8.24 | -4.60 | 0.884 |
| 0.900 | 71.7 | 69.89 | 0.64 | 467.0 | 64.45 | 17.81 | 0.078 | 64.45 | | 17.81 | 0.078 | | 200.2 | 11.45 | | 7.16 | 0.836 | 11.45 | 7.16 | 0.836 |
| 0.950 | 75.1 | 68.91 | 0.71 | 1873.8 | 45.17 | -16.57 | 0.344 | 45.17 | | -16.57 | 0.344 | | 662.3 | 8.14 | | -4.21 | 0.882 | 8.14 | -4.21 | 0.882 |
| 1.000 | 78.5 | 67.68 | 0.62 | 472.7 | 62.42 | 16.71 | 0.078 | 62.42 | | 16.71 | 0.078 | | 233.6 | 11.61 | | 6.75 | 0.828 | 11.61 | 6.75 | 0.828 |
| 1.050 | 81.9 | 66.61 | 0.70 | 1634.5 | 43.43 | -11.48 | 0.348 | 43.43 | | -11.48 | 0.348 | | 623.2 | 7.78 | | -3.45 | 0.883 | 7.78 | -3.45 | 0.883 |
| 1.100 | 85.2 | 65.51 | 0.47 | 505.9 | 62.75 | 4.72 | 0.042 | 62.75 | | 4.72 | 0.042 | | 303.5 | 12.01 | | 6.01 | 0.817 | 12.01 | 6.01 | 0.817 |
| 1.150 | 88.4 | 64.45 | 0.71 | 1668.9 | 42.06 | -8.22 | 0.347 | 42.06 | | -8.22 | 0.347 | | 607.6 | 7.57 | | -3.09 | 0.883 | 7.57 | -3.09 | 0.883 |
| 1.200 | 91.6 | 63.38 | 0.41 | 540.9 | 61.51 | -0.75 | 0.029 | 61.51 | | -0.75 | 0.029 | | 324.5 | 12.25 | | 5.55 | 0.807 | 12.25 | 5.55 | 0.807 |
| 1.250 | 94.8 | 62.29 | 0.74 | 1676.9 | 41.17 | -7.68 | 0.339 | 41.17 | | -7.68 | 0.339 | | 621.6 | 7.65 | | -3.27 | 0.877 | 7.65 | -3.27 | 0.877 |
| 1.300 | 97.9 | 61.30 | 0.40 | 554.0 | 59.65 | -2.13 | 0.025 | 59.65 | | -2.13 | 0.025 | | 332. | 12.25 | | 5.66 | 0.800 | 12.25 | 5.66 | 0.800 |
| 1.350 | 100.9 | 60.06 | 0.79 | 1882.3 | 41.21 | -8.08 | 0.314 | 41.21 | | -8.08 | 0.314 | | 649.6 | 7.91 | | -3.68 | 0.868 | 7.91 | -3.68 | 0.858 |
| 1.400 | 103.9 | 58.96 | 0.41 | 590.0 | 57.52 | -2.65 | 0.024 | 57.52 | | -2.65 | 0.024 | | 354.0 | 12.15 | | 5.42 | 0.794 | 12.15 | 5.42 | 0.794 |
| 1.450 | 106.8 | 57.76 | 0.84 | 1887.2 | 41.57 | -6.69 | 0.280 | 41.57 | | -6.69 | 0.280 | | 665.0 | 8.14 | | -3.73 | 0.859 | 8.14 | -3.73 | 0.359 |
| 1.500 | 109.7 | 56.65 | 0.45 | 756.2 | 55.04 | -4.29 | 0.028 | 55.04 | | -4.29 | 0.028 | | 431.6 | 12.12 | | 3.60 | 0.786 | 12.12 | 3.60 | 0.786 |
| 1.550 | 112.5 | 55.39 | 0.88 | 1765.6 | 41.55 | -0.61 | 0.250 | 41.55 | | -0.61 | 0.250 | | 639.9 | 8.09 | | -2.72 | 0.854 | 8.09 | -2.72 | 0.954 |
| 1.600 | 115.2 | 54.31 | 0.59 | 1165.2 | 51.80 | -6.18 | 0.046 | 51.80 | | -6.18 | 0.046 | | 516.0 | 12.12 | | 1.52 | 0.777 | 12.12 | 1.52 | 0.777 |
| 1.650 | 117.9 | 52.96 | 0.50 | 1346.8 | 43.90 | 13.30 | 0.171 | 43.90 | | 13.30 | 0.171 | | 553.5 | 8.00 | | -0.11 | 0.847 | 8.00 | -0.11 | 0.847 |
| 1.700 | 120.5 | 51.90 | 0.78 | 1628.7 | 47.46 | -4.37 | 0.086 | 47.46 | | -4.37 | 0.086 | | 611.7 | 11.11 | | -1.14 | 0.786 | 11.11 | -1.14 | 0.786 |
| 1.750 | 123.1 | 50.59 | 0.59 | 866.1 | 48.13 | 3.10 | 0.049 | 48.13 | | 3.10 | 0.049 | | 454.3 | 9.52 | | 3.07 | 0.812 | 9.52 | 3.07 | 0.912 |
| 1.800 | 125.6 | 49.46 | 0.88 | 2038.9 | 40.53 | -8.49 | 0.181 | 40.53 | | -8.49 | 0.181 | | 696.3 | 9.71 | | -3.66 | 0.804 | 9.71 | -3.66 | 0.804 |
| 1.850 | 128.0 | 48.27 | 0.66 | 1326.9 | 45.25 | -5.23 | 0.063 | 45.25 | | -5.23 | 0.063 | | 549.8 | 11.04 | | 0.77 | 0.771 | 11.04 | 0.77 | 0.771 |
| 1.900 | 130.4 | 46.95 | 0.84 | 1356.9 | 41.35 | 8.00 | 0.119 | 41.35 | | 8.00 | 0.119 | | 556.6 | 8.88 | | 0.18 | 0.811 | 8.88 | 0.18 | 0.811 |
| 1.950 | 132.7 | 45.88 | 0.85 | 1966.2 | 39.75 | -8.69 | 0.134 | 39.75 | | -8.69 | 0.134 | | 681.3 | 11.21 | | -2.85 | 0.756 | 11.21 | -2.85 | 0.755 |
| 2.000 | 135.0 | 44.55 | 0.62 | 841.2 | 41.93 | 6.19 | 0.059 | 41.93 | | 6.19 | 0.059 | | 449.1 | 10.02 | | 3.49 | 0.775 | 10.02 | 3.49 | 0.775 |
| 2.050 | 137.2 | 43.34 | 0.85 | 1814.1 | 36.34 | -4.24 | 0.162 | 36.34 | | -4.24 | 0.162 | | 650.0 | 9.49 | | -2.28 | 0.781 | 9.49 | -2.28 | 0.781 |
| 2.100 | 139.3 | 42.22 | 0.71 | 1479.4 | 38.95 | -5.46 | 0.078 | 38.95 | | -5.46 | 0.078 | | 580.9 | 11.79 | | 0.26 | 0.721 | 11.79 | 0.26 | 0.721 |
| 2.150 | 141.4 | 40.89 | 0.84 | 1103.5 | 31.02 | 15.75 | 0.241 | 31.02 | | 15.75 | 0.241 | | 503.3 | 8.91 | | 1.97 | 0.782 | 8.91 | 1.97 | 0.782 |
| 2.200 | 143.4 | 39.67 | 0.87 | 1900.4 | 34.21 | -5.18 | 0.137 | 34.21 | | -5.18 | 0.137 | | 667.8 | 10.45 | | -2.36 | 0.737 | 10.45 | -2.36 | 0.737 |
| 2.250 | 145.3 | 38.44 | 0.57 | 1009.2 | 36.71 | -3.16 | 0.045 | 36.71 | | -3.16 | 0.045 | | 483.8 | 11.28 | | 3.18 | 0.707 | 11.28 | 3.18 | 0.707 |
| 2.300 | 147.2 | 37.11 | 0.88 | 1654.2 | 26.20 | 2.44 | 0.294 | 26.20 | | 2.44 | 0.294 | | 616.9 | 8.75 | | -1.00 | 0.764 | 8.75 | -1.00 | 0.764 |
| 2.350 | 149.1 | 35.70 | 0.86 | 1300.8 | 32.30 | -3.97 | 0.100 | 32.30 | | -3.97 | 0.100 | | 647.2 | 11.41 | | -1.15 | 0.512 | 11.41 | -1.15 | 0.582 |
| 2.400 | 150.3 | 34.49 | 0.63 | 1032.5 | 32.77 | 0.82 | 0.049 | 32.77 | | 0.82 | 0.049 | | 488.6 | 9.92 | | 3.09 | 0.713 | 9.92 | 3.09 | 0.713 |
| 2.450 | 152.5 | 33.19 | 0.57 | 2028.2 | 28.53 | -1.70 | 0.140 | 28.53 | | -1.70 | 0.140 | | 694.1 | 9.84 | | -2.61 | 0.704 | 9.84 | -2.61 | 0.704 |
| 2.500 | 154.1 | 31.95 | 0.81 | 1444.3 | 29.51 | -3.23 | 0.076 | 29.51 | | -3.23 | 0.076 | | 614.9 | 11.68 | | 0.32 | 0.634 | 11.68 | 0.32 | 0.634 |
| 2.550 | 155.7 | 30.44 | 0.74 | 1206.5 | 28.52 | 2.25 | 0.063 | 28.52 | | 2.25 | 0.063 | | 541.0 | 9.29 | | 1.87 | 0.695 | 9.29 | 1.87 | 0.695 |
| 2.600 | 157.2 | 29.16 | 1.02 | 2238.9 | 24.94 | -4.47 | 0.145 | 24.94 | | -4.47 | 0.145 | | 737.6 | 10.71 | | -3.14 | 0.633 | 10.71 | -3.14 | 0.633 |
| 2.650 | 158.6 | 27.91 | 0.65 | 1177.0 | 26.54 | -2.86 | 0.046 | 26.54 | | -2.86 | 0.046 | | 518.4 | 11.60 | | 3.42 | 0.583 | 11.60 | 3.42 | 0.583 |
| 2.700 | 160.0 | 26.32 | 0.57 | 2050.1 | 17.71 | -2.44 | 0.327 | 17.71 | | -2.44 | 0.327 | | 691.7 | 8.97 | | -2.46 | 0.659 | 8.97 | -2.46 | 0.659 |
| 2.750 | 161.2 | 25.04 | 0.08 | 1812.0 | 22.86 | -3.30 | 0.087 | 22.86 | | -3.30 | 0.087 | | 649.5 | 11.05 | | -0.07 | 0.522 | 11.05 | -0.07 | 0.522 |
| 2.800 | 162.5 | 23.48 | 0.54 | 1265.5 | 20.92 | 17.56 | 0.109 | 20.92 | | 17.56 | 0.109 | | 536.7 | 9.18 | | 2.21 | 0.609 | 9.18 | 2.21 | 0.609 |
| 2.850 | 163.6 | 22.22 | 0.69 | 2311.4 | 17.99 | -9.72 | 0.191 | 17.99 | | -9.72 | 0.191 | | 752.6 | 12.08 | | -2.80 | 0.456 | 12.08 | -2.80 | 0.456 |
| 2.900 | 164.7 | 20.84 | 0.82 | 1019.4 | 2.87 | 14.95 | 0.863 | 2.87 | | 14.95 | 0.863 | | 485.9 | 0 44 | | 4.30 | 0.537 | 9.64 | 4.30 | 0.537 |
| 2.950 | 165.7 | 19.40 | 0.81 | 2421.3 | 2.57 | -25.93 | 0.868 | 2.57 | | -25.93 | 0.868 | | 775.3 | 1 4 | | -3.54 | 0.441 | 10.84 | -3.54 | 0.441 |
| 3.000 | 166.7 | 18.00 | 0.60 | 1267.5 | 7.68 | 11.93 | 0.576 | 7.68 | | 11.93 | 0.576 | | 533.9 | 12.07 | | 4.24 | 0.334 | 12.07 | 4.24 | 0.334 |

60 mph
.5 mv



[DX 708, p 15]

[DX 708, p 22]

35 mph
.2 mi

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.150 | 122.7 | 26.39 | 0.17 | 144.3 | 25.55 | | 1.06 | 0.030 | 25.55 | | 1.06 | 0.030 | 86.6 | 10.50 | | 4.91 | 0.621 | 10.50 | 4.91 | 0.621 |
| 3.200 | 124.0 | 25.95 | 0.27 | 369.9 | 18.02 | | 2.79 | 0.305 | 18.02 | | 2.79 | 0.305 | 221.9 | 6.71 | | 0.50 | 0.741 | 6.71 | 0.50 | 0.741 |
| 3.250 | 125.3 | 25.56 | 0.27 | 802.4 | 23.00 | -10.19 | 0.100 | 23.00 | -10.19 | 0.100 | | | 441.1 | 11.10 | | -5.10 | 0.556 | 11.10 | -5.10 | 0.556 |
| 3.300 | 126.5 | 25.14 | 0.26 | 282.8 | 13.30 | | 4.40 | 0.471 | 13.30 | | 4.40 | 0.471 | 169.7 | 5.68 | | 1.68 | 0.774 | 5.68 | 1.68 | 0.774 |
| 3.350 | 127.8 | 24.71 | 0.29 | 759.8 | 21.12 | | -7.25 | 0.145 | 21.12 | | -7.25 | 0.145 | 432.3 | 9.38 | | -5.07 | 0.620 | 9.38 | -5.07 | 0.620 |
| 3.400 | 129.0 | 24.23 | 0.18 | 155.9 | 23.44 | | 1.51 | 0.035 | 23.44 | | 1.51 | 0.035 | 93.5 | 9.87 | | 4.72 | 0.593 | 9.87 | 4.72 | 0.593 |
| 3.450 | 130.2 | 23.89 | 0.27 | 461.4 | 14.69 | | 0.04 | 0.385 | 14.69 | | 0.04 | 0.385 | 276.8 | 6.45 | | -1.04 | 0.730 | 6.45 | -1.04 | 0.730 |
| 3.500 | 131.4 | 23.48 | 0.19 | 394.1 | 22.59 | | -4.75 | 0.038 | 22.59 | | -4.75 | 0.038 | 236.4 | 11.34 | | 0.93 | 0.517 | 11.34 | 0.93 | 0.517 |
| 3.550 | 132.6 | 23.04 | 0.28 | 306.8 | 15.94 | | 5.07 | 0.308 | 15.94 | | 5.07 | 0.308 | 184.1 | 6.89 | | 1.73 | 0.731 | 6.89 | 1.73 | 0.731 |
| 3.600 | 133.7 | 22.65 | 0.29 | 999.8 | 18.00 | | -14.11 | 0.205 | 18.00 | | -14.11 | 0.205 | 481.9 | 10.11 | | -6.24 | 0.554 | 10.11 | -6.24 | 0.554 |
| 3.650 | 134.8 | 22.23 | 0.26 | 242.8 | 10.25 | | 5.50 | 0.539 | 10.25 | | 5.50 | 0.539 | 145.7 | 5.95 | | 2.72 | 0.733 | 5.95 | 2.72 | 0.733 |
| 3.700 | 135.9 | 21.78 | 0.29 | 713.6 | 17.18 | | -5.97 | 0.211 | 17.18 | | -5.97 | 0.211 | 422.8 | 8.77 | | -4.72 | 0.597 | 8.77 | -4.72 | 0.597 |
| 3.750 | 137.0 | 21.37 | 0.17 | 190.7 | 20.78 | | -0.50 | 0.028 | 20.78 | | -0.50 | 0.028 | 114.4 | 10.96 | | 4.53 | 0.457 | 10.96 | 4.53 | 0.457 |
| 3.800 | 138.1 | 20.94 | 0.27 | 362.2 | 12.25 | | 2.75 | 0.415 | 12.25 | | 2.75 | 0.415 | 217.3 | 6.63 | | 0.83 | 0.634 | 6.63 | 0.83 | 0.634 |
| 3.850 | 139.1 | 20.54 | 0.30 | 906.4 | 17.68 | | -11.35 | 0.139 | 17.68 | | -11.35 | 0.139 | 442.6 | 11.08 | | -5.35 | 0.460 | 11.08 | -5.35 | 0.460 |
| 3.900 | 140.1 | 20.13 | 0.23 | 299.4 | 4.33 | | 2.16 | 0.785 | 4.33 | | 2.16 | 0.785 | 179.7 | 5.30 | | 1.72 | 0.737 | 5.30 | 1.72 | 0.737 |
| 3.950 | 141.1 | 19.72 | 0.27 | 758.5 | 11.66 | | -8.76 | 0.409 | 11.66 | | -8.76 | 0.409 | 432.1 | 10.01 | | -4.58 | 0.492 | 10.01 | -4.58 | 0.492 |
| 4.000 | 142.1 | 19.31 | 0.26 | 184.8 | 9.27 | | 6.95 | 0.520 | 9.27 | | 6.95 | 0.520 | 110.9 | 9.48 | | 4.57 | 0.509 | 9.48 | 4.57 | 0.509 |
| 4.050 | 143.0 | 18.89 | 0.22 | 563.5 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 338.1 | 6.38 | | -2.52 | 0.662 | 6.38 | -2.52 | 0.662 |
| 4.100 | 144.0 | 18.53 | 0.25 | 135.0 | 4.48 | | 6.86 | 0.758 | 4.48 | | 6.86 | 0.758 | 81.0 | 10.60 | | 5.70 | 0.423 | 10.60 | 5.70 | 0.423 |
| 4.150 | 144.9 | 18.16 | 0.22 | 401.9 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 241.2 | 6.77 | | 0.44 | 0.627 | 6.77 | 0.44 | 0.627 |
| 4.200 | 145.8 | 17.78 | 0.24 | 783.6 | 1.85 | | -17.17 | 0.896 | 1.85 | | -17.17 | 0.896 | 470.3 | 11.21 | | -5.10 | 0.359 | 11.21 | -5.10 | 0.359 |
| 4.250 | 146.7 | 17.42 | 0.22 | 320.1 | 0.00 | | 0.06 | 1.000 | 0.00 | | 0.06 | 1.000 | 192.1 | 5.33 | | 1.65 | 0.694 | 5.33 | 1.65 | 0.694 |
| 4.300 | 147.5 | 17.04 | 0.25 | 761.2 | 3.97 | | -11.17 | 0.767 | 3.97 | | -11.17 | 0.767 | 432.6 | 10.53 | | -4.02 | 0.382 | 10.53 | -4.02 | 0.382 |
| 4.350 | 148.4 | 16.67 | 0.23 | 212.8 | 0.71 | | 3.41 | 0.957 | 0.71 | | 3.41 | 0.957 | 127.7 | 9.44 | | 4.53 | 0.434 | 9.44 | 4.53 | 0.434 |
| 4.400 | 149.2 | 16.29 | 0.22 | 590.3 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 354.2 | 6.61 | | -2.59 | 0.594 | 6.61 | -2.59 | 0.594 |
| 4.450 | 150.0 | 15.92 | 0.26 | 121.1 | 4.25 | | 7.44 | 0.733 | 4.25 | | 7.44 | 0.733 | 72.6 | 11.29 | | 6.65 | 0.291 | 11.29 | 6.65 | 0.291 |
| 4.500 | 150.8 | 15.54 | 0.22 | 583.3 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 350.0 | 4.96 | | -2.83 | 0.681 | 4.96 | -2.83 | 0.681 |
| 4.550 | 151.6 | 15.18 | 0.26 | 110.2 | 4.46 | | 7.99 | 0.706 | 4.46 | | 7.99 | 0.706 | 66.1 | 9.06 | | 6.36 | 0.403 | 9.06 | 6.36 | 0.403 |
| 4.600 | 152.3 | 14.78 | 0.23 | 432.0 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 259.2 | 7.83 | | 0.54 | 0.470 | 7.83 | 0.54 | 0.470 |
| 4.650 | 153.0 | 14.39 | 0.24 | 1013.1 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 494.6 | 9.74 | | -5.38 | 0.323 | 9.74 | -5.38 | 0.323 |
| 4.700 | 153.7 | 14.02 | 0.24 | 217.5 | 0.73 | | 3.53 | 0.948 | 0.73 | | 3.53 | 0.948 | 130.5 | 8.15 | | 4.39 | 0.419 | 8.15 | 4.39 | 0.419 |
| 4.750 | 154.4 | 13.62 | 0.23 | 1053.1 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 492.9 | 7.77 | | -6.05 | 0.430 | 7.77 | -6.05 | 0.430 |
| 4.800 | 155.1 | 13.26 | 0.23 | 198.9 | 1.09 | | 4.27 | 0.918 | 1.09 | | 4.27 | 0.918 | 119.3 | 6.34 | | 4.32 | 0.522 | 6.34 | 4.32 | 0.522 |
| 4.850 | 155.8 | 12.84 | 0.24 | 816.8 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 444.1 | 9.00 | | -4.16 | 0.299 | 9.00 | -4.16 | 0.299 |
| 4.900 | 156.4 | 12.44 | 0.23 | 344.7 | 1.97 | | 0.55 | 0.842 | 1.97 | | 0.55 | 0.842 | 206.8 | 11.43 | | 1.38 | 0.083 | 11.43 | 1.38 | 0.083 |
| 4.950 | 157.0 | 12.03 | 0.24 | 345.5 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 207.3 | 8.12 | | 2.53 | 0.328 | 8.12 | 2.53 | 0.328 |
| 5.000 | 157.6 | 11.70 | 0.23 | 617.1 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 370.3 | 8.60 | | -1.89 | 0.255 | 8.60 | -1.89 | 0.255 |
| 5.050 | 158.2 | 11.32 | 0.24 | 685.1 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 411.1 | 9.10 | | -2.78 | 0.196 | 9.10 | -2.78 | 0.196 |
| 5.100 | 158.7 | 10.94 | 0.24 | 670.0 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 402.0 | 8.76 | | -2.52 | 0.199 | 8.76 | -2.52 | 0.199 |
| 5.150 | 159.3 | 10.57 | 0.24 | 753.1 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 451.8 | 8.38 | | -3.36 | 0.207 | 8.38 | -3.36 | 0.207 |
| 5.200 | 159.8 | 10.21 | 0.21 | 518.5 | 1.51 | | -4.66 | 0.852 | 1.51 | | -4.66 | 0.852 | 311.1 | 9.58 | | -2.90 | 0.061 | 9.58 | -2.90 | 0.061 |
| 5.250 | 160.3 | 9.85 | 0.21 | 517.7 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 310.6 | 9.11 | | -1.98 | 0.075 | 9.11 | -1.98 | 0.075 |
| 5.300 | 160.8 | 9.51 | 0.22 | 494.0 | 0.33 | | -4.69 | 0.966 | 0.33 | | -4.69 | 0.966 | 296.4 | 8.79 | | -1.46 | 0.076 | 8.79 | -1.46 | 0.076 |
| 5.350 | 161.2 | 9.19 | 0.22 | 377.8 | 2.43 | | -0.01 | 0.735 | 2.43 | | -0.01 | 0.735 | 226.7 | 8.64 | | -0.51 | 0.060 | 8.64 | -0.51 | 0.060 |
| 5.400 | 161.7 | 8.90 | 0.15 | 261.8 | 0.51 | | -0.43 | 0.043 | 0.51 | | -0.43 | 0.043 | 157.1 | 8.56 | | -0.39 | 0.038 | 8.56 | -0.39 | 0.038 |
| 5.450 | 162.1 | 8.48 | 0.28 | 377.4 | 3.87 | | 1.11 | 0.544 | 3.87 | | 1.11 | 0.544 | 226.4 | 7.06 | | 2.81 | 0.158 | 7.06 | 2.81 | 0.158 |
| 5.500 | 162.5 | 8.05 | 0.27 | 659.2 | 3.81 | | -6.84 | 0.525 | 3.81 | | -6.84 | 0.526 | 395.5 | 6.04 | | -2.42 | 0.249 | 6.04 | -2.42 | 0.249 |
| 5.550 | 162.9 | 7.67 | 0.09 | 124.5 | 7.45 | | 1.35 | 0.028 | 7.45 | | 1.35 | 0.028 | 74.7 | 7.53 | | 0.04 | 0.019 | 7.53 | 0.04 | 0.019 |
| 5.600 | 163.3 | 7.40 | 0.29 | 712.1 | 4.34 | | -7.62 | 0.414 | 4.34 | | -7.62 | 0.414 | 422.5 | 5.77 | | -3.10 | 0.220 | 5.77 | -3.10 | 0.220 |
| 5.650 | 163.7 | 7.01 | 0.13 | 139.1 | 6.70 | | 3.21 | 0.044 | 6.70 | | 3.21 | 0.044 | 83.4 | 6.86 | | 0.01 | 0.021 | 6.86 | 0.01 | 0.021 |
| 5.700 | 164.0 | 6.76 | 0.29 | 728.6 | 4.48 | | -7.57 | 0.337 | 4.48 | | -7.57 | 0.337 | 429.9 | 5.46 | | -3.06 | 0.102 | 5.46 | -3.06 | 0.102 |
| 5.750 | 164.3 | 6.37 | 0.31 | 153.6 | 4.61 | | 9.30 | 0.276 | 4.61 | | 9.30 | 0.276 | 92.1 | 6.22 | | -0.02 | 0.023 | 6.22 | -0.02 | 0.023 |
| 5.800 | 164.7 | 6.11 | 0.30 | 710.4 | 4.56 | | -6.69 | 0.294 | 4.56 | | -6.69 | 0.294 | 423.4 | 5.15 | | -2.92 | 0.100 | 5.15 | -2.92 | 0.100 |
| 5.850 | 164.9 | 5.73 | 0.16 | 101.2 | 1.60 | | 5.83 | 0.721 | 1.60 | | 5.83 | 0.721 | 100.7 | 5.57 | | 0.05 | 0.028 | 5.57 | 0.05 | 0.028 |
| 5.900 | 165.2 | 5.40 | 0.30 | 680.0 | 4.70 | | -2.78 | 0.143 | 4.70 | | -2.78 | 0.143 | 340.0 | 4.68 | | -1.63 | 0.109 | 4.68 | -1.63 | 0.109 |
| 5.950 | 165.5 | 5.00 | 0.25 | 228.5 | 0.58 | | 3.45 | 0.886 | 0.58 | | 3.45 | 0.886 | 137.0 | 4.51 | | 4.67 | 0.113 | 4.51 | 4.67 | 0.113 |
| 6.000 | 165.7 | 4.85 | 0.23 | 435.4 | 4.46 | | -1.18 | 0.000 | 4.46 | | -1.18 | 0.000 | 256.2 | 4.53 | | -0.96 | 0.087 | 4.53 | -0.96 | 0.087 |
| 6.050 | 166.0 | 4.46 | 0.22 | 307.2 | 0.01 | | 0.48 | 0.997 | 0.01 | | 0.48 | 0.997 | 184.3 | 1.77 | | 2.34 | 0.603 | 1.77 | 2.34 | 0.603 |
| 6.100 | 166.2 | 4.21 | 0.13 | 244.4 | 4.05 | | -0.58 | 0.039 | 4.05 | | -0.58 | 0.039 | 146.7 | 4.07 | | -0.51 | 0.033 | 4.07 | -0.51 | 0.033 |
| 6.150 | 166.4 | 3.33 | 0.21 | 414.7 | 0.0 | | 0.0 | 1.000 | 0.0 | | 0.0 | 1.000 | 248.8 | 0.42 | | -0.64 | 0.991 | 0.42 | -0.64 | 0.991 |
| 6.200 | 166.6 | 3.56 | 0.06 | 115.6 | 3.49 | | -0.20 | 0.017 | 3.49 | | -0.20 | 0.017 | 69.4 | 3.60 | | 0.01 | 0.000 | 3.60 | 0.01 | 0.000 |

E-1291

[DX 708, p 22]

25 mol
.2 mL

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.0 | 36.67 | 0.01 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | | |
| 0.050 | 1.8 | 35.45 | 0.29 | 663.6 | 31.99 | -5.79 | 0.133 | 31.99 | -5.79 | 0.133 | 398.2 | 33.34 | -3.17 | 0.085 | 33.34 | -3.17 | 0.085 | | |
| 0.100 | 3.6 | 35.96 | 0.26 | 1190.4 | 8.13 | -23.80 | 0.774 | 8.13 | -23.80 | 0.774 | 510.2 | 27.15 | -5.50 | 0.245 | 27.15 | -5.50 | 0.245 | | |
| 0.150 | 5.4 | 35.58 | 0.23 | 1582.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 602.2 | 15.07 | -9.52 | 0.577 | 15.07 | -9.52 | 0.577 | | |
| 0.200 | 7.2 | 35.23 | 0.20 | 607.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 364.7 | 1.18 | -4.43 | 0.956 | 1.18 | -4.43 | 0.956 | | |
| 0.250 | 9.0 | 34.90 | 0.22 | 114.0 | 3.66 | 6.61 | 0.895 | 3.66 | 6.61 | 0.895 | 68.9 | 2.51 | 4.07 | 0.928 | 2.51 | 4.07 | 0.928 | | |
| 0.300 | 10.7 | 34.53 | 0.23 | 649.6 | 7.27 | -7.85 | 0.789 | 7.27 | -7.85 | 0.789 | 399.7 | 4.37 | -5.00 | 0.873 | 4.37 | -5.00 | 0.873 | | |
| 0.350 | 12.4 | 34.17 | 0.24 | 123.3 | 9.23 | 7.66 | 0.730 | 9.23 | 7.66 | 0.730 | 77.0 | 4.99 | 4.00 | 0.854 | 4.99 | 4.00 | 0.854 | | |
| 0.400 | 14.1 | 33.76 | 0.25 | 652.4 | 17.80 | -5.55 | 0.473 | 17.80 | -5.55 | 0.473 | 391.5 | 8.49 | -4.62 | 0.748 | 8.49 | -4.62 | 0.748 | | |
| 0.450 | 15.8 | 33.33 | 0.27 | 156.8 | 20.39 | 9.28 | 0.388 | 20.39 | 9.28 | 0.388 | 95.3 | 7.79 | 3.82 | 0.766 | 7.79 | 3.82 | 0.766 | | |
| 0.500 | 17.4 | 32.87 | 0.29 | 393.9 | 27.32 | 4.07 | 0.169 | 27.32 | 4.07 | 0.169 | 236.4 | 8.34 | -0.13 | 0.746 | 8.34 | -0.13 | 0.746 | | |
| 0.550 | 19.1 | 32.47 | 0.29 | 609.2 | 28.53 | -2.51 | 0.122 | 28.53 | -2.51 | 0.122 | 365.5 | 9.03 | -3.69 | 0.722 | 9.03 | -3.69 | 0.722 | | |
| 0.600 | 20.7 | 32.09 | 0.23 | 575.0 | 30.06 | -6.19 | 0.063 | 30.06 | -6.19 | 0.063 | 345.0 | 10.52 | -2.84 | 0.672 | 10.52 | -2.84 | 0.672 | | |
| 0.650 | 22.3 | 31.68 | 0.18 | 181.1 | 30.56 | 1.17 | 0.035 | 30.56 | 1.17 | 0.035 | 108.7 | 10.10 | 3.98 | 0.681 | 10.10 | 3.98 | 0.681 | | |
| 0.700 | 23.8 | 31.26 | 0.24 | 263.9 | 29.03 | 3.35 | 0.071 | 29.03 | 3.35 | 0.071 | 158.3 | 8.76 | 2.48 | 0.720 | 8.76 | 2.48 | 0.720 | | |
| 0.750 | 25.4 | 30.87 | 0.29 | 400.0 | 26.99 | 2.94 | 0.126 | 26.99 | 2.94 | 0.126 | 240.0 | 8.44 | 0.18 | 0.727 | 8.44 | 0.18 | 0.727 | | |
| 0.800 | 26.9 | 30.47 | 0.29 | 541.0 | 25.95 | -0.98 | 0.149 | 25.95 | -0.98 | 0.149 | 324.6 | 8.58 | -2.18 | 0.718 | 8.58 | -2.18 | 0.718 | | |
| 0.850 | 28.4 | 30.08 | 0.28 | 693.9 | 26.71 | -6.52 | 0.112 | 26.71 | -6.52 | 0.112 | 416.4 | 9.89 | -4.61 | 0.671 | 9.89 | -4.61 | 0.671 | | |
| 0.900 | 29.9 | 29.66 | 0.20 | 389.2 | 28.19 | -3.35 | 0.050 | 28.19 | -3.35 | 0.050 | 233.5 | 10.77 | 0.75 | 0.637 | 10.77 | 0.75 | 0.637 | | |
| 0.950 | 31.4 | 29.24 | 0.21 | 205.4 | 27.56 | 2.74 | 0.057 | 27.56 | 2.74 | 0.057 | 123.2 | 9.96 | 3.76 | 0.669 | 9.96 | 3.76 | 0.669 | | |
| 1.000 | 33.0 | 28.83 | 0.25 | 253.2 | 26.37 | 4.01 | 0.055 | 26.37 | 4.01 | 0.085 | 151.9 | 9.22 | 2.81 | 0.680 | 9.22 | 2.81 | 0.680 | | |
| 1.050 | 34.3 | 28.42 | 0.27 | 319.1 | 24.85 | 4.33 | 0.126 | 24.85 | 4.33 | 0.126 | 191.5 | 8.55 | 1.56 | 0.699 | 8.55 | 1.56 | 0.699 | | |
| 1.100 | 35.7 | 28.03 | 0.28 | 437.9 | 23.53 | 1.26 | 0.161 | 23.53 | 1.26 | 0.161 | 262.8 | 8.43 | -0.52 | 0.699 | 8.43 | -0.52 | 0.699 | | |
| 1.150 | 37.1 | 27.63 | 0.28 | 621.6 | 22.90 | -3.97 | 0.171 | 22.90 | -3.97 | 0.171 | 373.0 | 8.58 | -3.66 | 0.689 | 8.58 | -3.66 | 0.689 | | |
| 1.200 | 38.5 | 27.24 | 0.19 | 394.9 | 26.11 | -4.60 | 0.041 | 26.11 | -4.60 | 0.041 | 236.9 | 11.19 | 0.60 | 0.509 | 11.19 | 0.60 | 0.509 | | |
| 1.250 | 39.8 | 26.80 | 0.27 | 241.9 | 24.03 | 5.99 | 0.103 | 24.03 | 5.99 | 0.103 | 145.1 | 8.68 | 2.89 | 0.676 | 8.68 | 2.89 | 0.676 | | |
| 1.300 | 41.1 | 26.41 | 0.28 | 475.9 | 21.24 | 0.58 | 0.196 | 21.24 | 0.58 | 0.196 | 285.5 | 8.10 | -1.18 | 0.693 | 8.10 | -1.18 | 0.693 | | |
| 1.350 | 42.5 | 26.03 | 0.20 | 699.0 | 23.18 | -6.12 | 0.109 | 23.18 | -6.12 | 0.109 | 413.4 | 10.31 | -4.49 | 0.654 | 10.31 | -4.49 | 0.654 | | |
| 1.400 | 43.7 | 25.69 | 0.18 | 209.9 | 24.69 | 0.18 | 0.035 | 24.69 | 0.18 | 0.035 | 126.0 | 10.49 | 3.80 | 0.590 | 10.49 | 3.80 | 0.590 | | |
| 1.450 | 45.0 | 25.17 | 0.23 | 251.8 | 23.48 | 3.24 | 0.067 | 23.48 | 3.24 | 0.067 | 151.1 | 9.02 | 2.90 | 0.642 | 9.02 | 2.90 | 0.642 | | |
| 1.500 | 46.3 | 24.76 | 0.29 | 367.2 | 21.73 | 4.14 | 0.122 | 21.73 | 4.14 | 0.122 | 220.3 | 8.42 | 0.86 | 0.660 | 8.42 | 0.86 | 0.660 | | |
| 1.550 | 47.5 | 24.36 | 0.30 | 554.8 | 20.67 | 0.76 | 0.151 | 20.67 | 0.76 | 0.151 | 332.9 | 8.66 | -1.43 | 0.645 | 8.66 | -1.43 | 0.645 | | |
| 1.600 | 48.7 | 23.95 | 0.30 | 651.3 | 20.35 | -3.44 | 0.150 | 20.35 | -3.44 | 0.150 | 390.8 | 9.07 | -3.85 | 0.621 | 9.07 | -3.85 | 0.621 | | |
| 1.650 | 49.9 | 23.55 | 0.26 | 632.8 | 21.57 | -5.91 | 0.084 | 21.57 | -5.91 | 0.084 | 379.7 | 10.57 | -3.25 | 0.551 | 10.57 | -3.25 | 0.551 | | |
| 1.700 | 51.1 | 23.11 | 0.19 | 200.5 | 22.28 | 0.63 | 0.036 | 22.28 | 0.63 | 0.036 | 120.3 | 10.31 | 4.16 | 0.554 | 10.31 | 4.16 | 0.554 | | |
| 1.750 | 52.2 | 22.68 | 0.25 | 267.1 | 20.95 | 3.64 | 0.076 | 20.95 | 3.64 | 0.076 | 160.3 | 9.19 | 2.04 | 0.595 | 9.19 | 2.04 | 0.595 | | |
| 1.800 | 53.3 | 22.27 | 0.28 | 341.1 | 19.59 | 4.35 | 0.120 | 19.59 | 4.35 | 0.120 | 204.7 | 8.86 | 1.53 | 0.602 | 8.86 | 1.53 | 0.602 | | |
| 1.850 | 54.4 | 21.85 | 0.29 | 421.7 | 18.02 | 2.30 | 0.175 | 18.02 | 2.30 | 0.175 | 253.0 | 8.55 | 0.11 | 0.609 | 8.55 | 0.11 | 0.609 | | |
| 1.900 | 55.5 | 21.44 | 0.29 | 529.3 | 17.52 | -0.98 | 0.183 | 17.52 | -0.98 | 0.183 | 317.6 | 8.90 | -1.66 | 0.565 | 8.90 | -1.66 | 0.565 | | |
| 1.950 | 56.6 | 21.02 | 0.29 | 666.8 | 17.26 | -5.59 | 0.179 | 17.26 | -5.59 | 0.179 | 412.1 | 9.40 | -4.26 | 0.553 | 9.40 | -4.26 | 0.553 | | |
| 2.000 | 57.6 | 20.60 | 0.27 | 629.3 | 18.61 | -5.64 | 0.097 | 18.61 | -5.64 | 0.097 | 377.6 | 10.58 | -3.03 | 0.487 | 10.58 | -3.03 | 0.487 | | |
| 2.050 | 58.6 | 20.17 | 0.21 | 324.9 | 19.16 | -1.47 | 0.050 | 19.16 | -1.47 | 0.050 | 194.9 | 10.75 | 2.24 | 0.467 | 10.75 | 2.24 | 0.467 | | |
| 2.100 | 59.6 | 19.73 | 0.22 | 218.4 | 18.53 | 2.88 | 0.061 | 18.53 | 2.88 | 0.061 | 131.0 | 10.21 | 4.02 | 0.483 | 10.21 | 4.02 | 0.483 | | |
| 2.150 | 60.6 | 19.30 | 0.28 | 300.2 | 15.62 | 5.34 | 0.191 | 15.62 | 5.34 | 0.191 | 180.1 | 8.87 | 2.39 | 0.541 | 8.87 | 2.39 | 0.541 | | |
| 2.200 | 61.6 | 18.87 | 0.28 | 419.1 | 14.32 | 1.72 | 0.241 | 14.32 | 1.72 | 0.241 | 251.5 | 8.49 | 0.31 | 0.550 | 8.49 | 0.31 | 0.550 | | |
| 2.250 | 62.5 | 18.44 | 0.20 | 561.4 | 14.09 | -2.22 | 0.236 | 14.09 | -2.22 | 0.236 | 336.8 | 8.79 | -2.04 | 0.524 | 8.79 | -2.04 | 0.524 | | |
| 2.300 | 63.4 | 18.01 | 0.29 | 711.1 | 14.73 | -6.05 | 0.182 | 14.73 | -6.05 | 0.182 | 422.3 | 9.62 | -4.27 | 0.456 | 9.62 | -4.27 | 0.456 | | |
| 2.350 | 64.3 | 17.58 | 0.28 | 643.8 | 15.78 | -5.26 | 0.102 | 15.78 | -5.26 | 0.102 | 386.3 | 10.68 | -2.96 | 0.393 | 10.68 | -2.96 | 0.393 | | |
| 2.400 | 65.2 | 17.13 | 0.21 | 302.6 | 16.36 | -0.92 | 0.046 | 16.36 | -0.92 | 0.046 | 181.6 | 10.77 | 2.98 | 0.371 | 10.77 | 2.98 | 0.371 | | |
| 2.450 | 66.0 | 16.67 | 0.25 | 282.4 | 15.46 | 4.02 | 0.073 | 15.46 | 4.02 | 0.073 | 145.4 | 9.87 | 3.87 | 0.408 | 9.87 | 3.87 | 0.408 | | |
| 2.500 | 66.8 | 16.23 | 0.30 | 332.0 | 13.10 | 5.28 | 0.192 | 13.10 | 5.28 | 0.192 | 192.2 | 8.99 | 2.19 | 0.446 | 8.99 | 2.19 | 0.446 | | |
| 2.550 | 67.6 | 15.79 | 0.29 | 499.2 | 10.47 | -0.35 | 0.337 | 10.47 | -0.35 | 0.337 | 299.5 | 8.36 | -0.78 | 0.476 | 8.36 | -0.78 | 0.476 | | |
| 2.600 | 68.4 | 15.33 | 0.31 | 741.6 | 11.80 | -6.59 | 0.230 | 11.80 | -6.59 | 0.230 | 428.6 | 9.62 | -4.12 | 0.372 | 9.62 | -4.12 | 0.372 | | |
| 2.650 | 69.2 | 14.88 | 0.24 | 632.9 | 13.38 | -4.60 | 0.101 | 13.38 | -4.60 | 0.101 | 379.8 | 10.96 | -2.32 | 0.264 | 10.96 | -2.32 | 0.264 | | |
| 2.700 | 69.9 | 14.41 | 0.22 | 230.8 | 13.42 | 4.00 | 0.068 | 13.42 | 4.00 | 0.068 | 138.5 | 10.56 | 4.56 | 0.257 | 10.56 | 4.56 | 0.257 | | |
| 2.750 | 70.6 | 13.95 | 0.28 | 320.4 | 9.17 | 4.62 | 0.343 | 9.17 | 4.62 | 0.343 | 192.2 | 8.93 | 2.67 | 0.350 | 8.93 | 2.67 | 0.350 | | |
| 2.800 | 71.3 | 13.48 | 0.29 | 485.3 | 7.50 | -0.82 | 0.444 | 7.50 | -0.82 | 0.444 | 291.2 | 8.51 | -0.21 | 0.369 | 8.51 | -0.21 | 0.369 | | |
| 2.850 | 71.9 | 13.01 | 0.29 | 731.1 | 7.64 | -7.63 | 0.390 | 7.64 | -7.63 | 0.390 | 426.4 | 9.36 | -3.77 | 0.280 | 9.36 | -3.77 | 0.280 | | |
| 2.900 | 72.6 | 12.55 | 0.30 | 711.6 | 8.73 | -6.65 | 0.305 | 8.73 | -6.65 | 0.305 | 422.4 | 10.78 | -3.21 | 0.141 | 10.78 | -3.21 | 0.141 | | |
| 2.950 | 73.2 | 12.13 | 0.25 | 297.1 | 4.10 | 2.95 | 0.662 | 4.10 | 2.95 | 0.662 | 178.2 | 10.58 | 2.62 | 0.094 | 10.58 | 2.62 | 0.094 | | |
| 3.000 | 73.8 | 11.74 | 0.23 | 255.6 | 0.26 | 2.15 | 0.678 | 0.26 | 2.15 | 0.678 | 153.4 | 10.65 | 3.28 | 0.092 | 10.65 | 3.28 | 0.092 | | |
| 3.050 | 74.4 | 11.37 | 0.20 | 278.3 | 0.20 | 1.41 | 0.682 | 0.26 | 1.41 | 0.682 | 167.0 | 10.63 | 1.36 | 0.065 | 10.63 | 1.36 | 0.065 | | |

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[DX 708, p 31]

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3000. | 5.33 | 7.87 | 13.00 | 58.65 | .030 | .020 | .030 | 0.51 | 0.39 | 250.0 | 150.0 | 0.92 | 700. | .344 | 20.0 | | | | | | |
| 0.000 | 0.0 | 22.60 | 0.00 | 0.0 | 22.00 | | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | 0.0 | 22.00 | | | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | 15 mgb |
| 0.050 | 1.1 | 21.74 | 0.29 | 663.6 | 18.13 | | -5.68 | 0.166 | 18.13 | -5.68 | 0.166 | 398.2 | 19.58 | | | -2.43 | 0.100 | 19.58 | -2.43 | 0.100 | 2 mm |
| 0.100 | 2.2 | 21.31 | 0.23 | 1180.4 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 519.2 | 13.36 | | | -6.04 | 0.373 | 13.36 | -6.04 | 0.373 | |
| 0.150 | 3.2 | 20.95 | 0.21 | 434.2 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 260.5 | 4.93 | | | -0.47 | 0.765 | 4.93 | -0.47 | 0.765 | |
| 0.200 | 4.3 | 20.60 | 0.25 | 139.8 | 5.95 | | 6.77 | 0.711 | 5.95 | 6.77 | 0.711 | 83.9 | 10.75 | | | 5.48 | 0.478 | 10.75 | 5.48 | 0.478 | |
| 0.250 | 5.3 | 20.22 | 0.22 | 366.2 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 219.7 | 8.43 | | | 1.01 | 0.583 | 8.43 | 1.01 | 0.583 | |
| 0.300 | 6.3 | 19.85 | 0.22 | 605.8 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 363.5 | 10.08 | | | -2.88 | 0.492 | 10.08 | -2.88 | 0.492 | |
| 0.350 | 7.3 | 19.48 | 0.23 | 640.2 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 384.1 | 11.08 | | | -3.28 | 0.432 | 11.08 | -3.28 | 0.432 | |
| 0.400 | 8.2 | 19.12 | 0.24 | 206.0 | 1.49 | | 4.41 | 0.922 | 1.49 | 4.41 | 0.922 | 123.6 | 10.51 | | | 4.14 | 0.450 | 10.51 | 4.14 | 0.450 | |
| 0.450 | 9.2 | 18.74 | 0.24 | 370.6 | 0.29 | | -0.60 | 0.984 | 0.29 | -0.60 | 0.984 | 222.4 | 11.23 | | | 1.55 | 0.401 | 11.23 | 1.55 | 0.401 | |
| 0.500 | 10.1 | 18.36 | 0.24 | 228.7 | 0.78 | | 3.69 | 0.958 | 0.78 | 3.69 | 0.958 | 137.2 | 10.58 | | | 3.97 | 0.424 | 10.58 | 3.97 | 0.424 | |
| 0.550 | 11.0 | 17.98 | 0.23 | 387.7 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 232.6 | 8.45 | | | 0.93 | 0.530 | 8.45 | 0.93 | 0.530 | |
| 0.600 | 11.9 | 17.60 | 0.24 | 604.3 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 362.6 | 10.00 | | | -2.32 | 0.432 | 10.00 | -2.32 | 0.432 | |
| 0.650 | 12.8 | 17.21 | 0.24 | 775.7 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 465.4 | 9.68 | | | -4.34 | 0.438 | 9.68 | -4.34 | 0.438 | |
| 0.700 | 13.6 | 16.83 | 0.25 | 497.1 | 1.14 | | -4.21 | 0.932 | 1.14 | -4.21 | 0.932 | 298.3 | 11.37 | | | 0.11 | 0.324 | 11.37 | 0.11 | 0.324 | |
| 0.750 | 14.5 | 16.45 | 0.24 | 248.8 | 0.39 | | 2.47 | 0.976 | 0.39 | 2.47 | 0.976 | 149.3 | 11.07 | | | 4.42 | 0.327 | 11.07 | 4.42 | 0.327 | |
| 0.800 | 15.3 | 16.07 | 0.23 | 334.9 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 201.0 | 8.69 | | | 2.44 | 0.439 | 8.69 | 2.44 | 0.439 | |
| 0.850 | 16.1 | 15.69 | 0.23 | 659.7 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 395.8 | 9.35 | | | -2.94 | 0.404 | 9.35 | -2.94 | 0.404 | |
| 0.900 | 16.8 | 15.31 | 0.23 | 840.8 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 449.1 | 10.76 | | | -4.08 | 0.297 | 10.76 | -4.08 | 0.297 | |
| 0.950 | 17.6 | 14.93 | 0.24 | 217.5 | 0.70 | | 2.96 | 0.953 | 0.70 | 2.96 | 0.953 | 130.5 | 10.69 | | | 5.04 | 0.285 | 10.69 | 5.04 | 0.285 | |
| 1.000 | 18.3 | 14.57 | 0.23 | 380.3 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 228.2 | 9.27 | | | 1.89 | 0.354 | 9.27 | 1.89 | 0.354 | |
| 1.050 | 19.1 | 14.20 | 0.22 | 662.1 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 397.2 | 8.26 | | | -3.21 | 0.418 | 8.26 | -3.21 | 0.418 | |
| 1.100 | 19.8 | 13.83 | 0.24 | 683.9 | 1.30 | | -10.14 | 0.906 | 1.30 | -10.14 | 0.906 | 410.3 | 11.88 | | | -2.63 | 0.141 | 11.88 | -2.63 | 0.141 | |
| 1.150 | 20.4 | 13.46 | 0.23 | 311.4 | 0.00 | | 0.05 | 1.000 | 0.00 | 0.05 | 1.000 | 186.8 | 7.96 | | | 2.80 | 0.409 | 7.96 | 2.80 | 0.409 | |
| 1.200 | 21.1 | 13.08 | 0.23 | 838.6 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 448.6 | 9.01 | | | -4.34 | 0.312 | 9.01 | -4.34 | 0.312 | |
| 1.250 | 21.7 | 12.71 | 0.24 | 175.5 | 1.96 | | 5.08 | 0.846 | 1.96 | 5.08 | 0.846 | 105.3 | 11.40 | | | 5.22 | 0.103 | 11.40 | 5.22 | 0.103 | |
| 1.300 | 22.4 | 12.33 | 0.24 | 310.5 | 0.01 | | 0.44 | 0.999 | 0.01 | 0.44 | 0.999 | 186.3 | 9.66 | | | 3.54 | 0.217 | 9.66 | 3.54 | 0.217 | |
| 1.350 | 23.0 | 11.95 | 0.22 | 374.2 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 224.5 | 10.90 | | | 1.16 | 0.088 | 10.90 | 1.16 | 0.088 | |
| 1.400 | 23.6 | 11.58 | 0.22 | 547.3 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 328.4 | 10.63 | | | -2.12 | 0.082 | 10.63 | -2.12 | 0.082 | |
| 1.450 | 24.1 | 11.21 | 0.24 | 492.9 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 295.7 | 9.95 | | | 0.16 | 0.113 | 9.95 | 0.16 | 0.113 | |
| 1.500 | 24.7 | 10.86 | 0.21 | 304.7 | 0.06 | | 1.05 | 0.995 | 0.06 | 1.05 | 0.995 | 182.8 | 10.19 | | | 0.79 | 0.062 | 10.19 | 0.79 | 0.062 | |
| 1.550 | 25.2 | 10.53 | 0.19 | 210.2 | 1.04 | | 4.37 | 0.901 | 1.04 | 4.37 | 0.901 | 126.1 | 10.14 | | | 0.34 | 0.036 | 10.14 | 0.34 | 0.036 | |
| 1.600 | 25.7 | 10.19 | 0.21 | 269.0 | 4.93 | | 5.06 | 0.516 | 4.93 | 5.06 | 0.516 | 161.4 | 9.08 | | | -1.26 | 0.030 | 9.08 | -1.26 | 0.030 | |
| 1.650 | 26.2 | 9.83 | 0.21 | 426.3 | 9.17 | | -1.79 | 0.067 | 9.17 | -1.79 | 0.067 | 255.8 | 9.27 | | | -1.55 | 0.057 | 9.27 | -1.55 | 0.057 | |
| 1.700 | 26.7 | 9.56 | 0.18 | 295.1 | 9.05 | | 0.21 | 0.054 | 9.05 | 0.21 | 0.054 | 177.1 | 9.10 | | | 0.00 | 0.048 | 9.10 | 0.00 | 0.048 | |
| 1.750 | 27.2 | 9.38 | 0.13 | 220.5 | 9.03 | | 0.02 | 0.037 | 9.03 | 0.02 | 0.037 | 132.3 | 9.06 | | | -0.01 | 0.034 | 9.06 | -0.01 | 0.034 | |
| 1.800 | 27.7 | 9.0. | 0.30 | 526.2 | 6.00 | | -1.89 | 0.334 | 6.00 | -1.89 | 0.334 | 315.7 | 7.62 | | | 0.51 | 0.154 | 7.62 | 0.51 | 0.154 | |
| 1.850 | 28.1 | 8.59 | 0.30 | 515.7 | 7.11 | | -3.68 | 0.172 | 7.11 | -3.68 | 0.172 | 309.4 | 7.59 | | | -1.58 | 0.116 | 7.59 | -1.58 | 0.116 | |
| 1.900 | 28.5 | 8.16 | 0.23 | 232.7 | 6.20 | | 6.76 | 0.241 | 6.20 | 6.76 | 0.241 | 139.6 | 7.88 | | | -0.23 | 0.034 | 7.88 | -0.23 | 0.034 | |
| 1.950 | 28.9 | 7.76 | 0.27 | 484.2 | 3.85 | | -2.04 | 0.504 | 3.85 | -2.04 | 0.504 | 290.5 | 6.23 | | | 0.73 | 0.197 | 6.23 | 0.73 | 0.197 | |
| 2.000 | 29.3 | 7.39 | 0.27 | 504.6 | 6.57 | | -1.57 | 0.110 | 6.57 | -1.57 | 0.110 | 302.8 | 6.74 | | | -1.12 | 0.088 | 6.74 | -1.12 | 0.088 | |
| 2.050 | 29.6 | 6.96 | 0.22 | 224.4 | 4.41 | | 6.22 | 0.367 | 4.41 | 6.22 | 0.367 | 134.6 | 6.69 | | | 0.16 | 0.038 | 6.69 | 0.16 | 0.038 | |
| 2.100 | 30.0 | 6.58 | 0.27 | 622.0 | 3.24 | | -5.91 | 0.507 | 3.24 | -5.91 | 0.507 | 373.2 | 4.90 | | | -2.11 | 0.255 | 4.90 | -2.11 | 0.255 | |
| 2.150 | 30.3 | 6.21 | 0.16 | 284.1 | 5.92 | | -0.56 | 0.048 | 5.92 | -0.56 | 0.048 | 170.5 | 5.95 | | | -0.52 | 0.042 | 5.95 | -0.52 | 0.042 | |
| 2.200 | 30.6 | 5.81 | 0.35 | 376.0 | 1.54 | | 0.04 | 0.734 | 1.54 | 0.04 | 0.734 | 225.6 | 4.37 | | | -2.15 | 0.247 | 4.37 | 2.15 | 0.247 | |
| 2.250 | 30.9 | 5.47 | 0.26 | 486.3 | 4.93 | | -1.13 | 0.099 | 4.93 | -1.13 | 0.099 | 291.8 | 5.00 | | | -0.94 | 0.087 | 5.00 | -0.94 | 0.087 | |
| 2.300 | 31.1 | 5.05 | 0.21 | 240.6 | 0.93 | | 3.70 | 0.815 | 0.93 | 3.70 | 0.815 | 144.4 | 4.79 | | | 1.05 | 0.052 | 4.79 | 1.05 | 0.052 | |
| 2.350 | 31.4 | 4.70 | 0.31 | 632.3 | 3.76 | | -3.61 | 0.201 | 3.76 | -3.61 | 0.201 | 379.4 | 4.01 | | | -1.74 | 0.148 | 4.01 | -1.74 | 0.148 | |
| 2.400 | 31.6 | 4.31 | 0.20 | 182.4 | 1.97 | | 7.28 | 0.543 | 1.97 | 7.28 | 0.543 | 109.4 | 4.19 | | | -0.03 | 0.028 | 4.19 | -0.03 | 0.028 | |
| 2.450 | 31.8 | 3.96 | 0.29 | 704.5 | 2.33 | | -6.80 | 0.413 | 2.33 | -6.80 | 0.413 | 420.9 | 3.01 | | | -3.16 | 0.242 | 3.01 | -3.16 | 0.242 | |
| 2.500 | 32.0 | 3.59 | 0.12 | 159.1 | 3.45 | | 2.30 | 0.039 | 3.45 | 2.30 | 0.039 | 95.5 | 3.50 | | | -0.10 | 0.023 | 3.50 | -0.10 | 0.023 | |
| 2.550 | 32.2 | 3.25 | 0.26 | 727.6 | 0.78 | | -9.66 | 0.761 | 0.78 | -9.66 | 0.761 | 425.7 | 2.07 | | | -3.67 | 0.363 | 2.07 | -3.67 | 0.363 | |
| 2.600 | 32.3 | 2.89 | 0.09 | 149.0 | 2.83 | | 0.01 | 0.023 | 2.83 | 0.01 | 0.023 | 89.4 | 2.83 | | | -0.01 | 0.022 | 2.83 | -0.01 | 0.022 | |
| 2.650 | 32.5 | 2.77 | 0.18 | 322.7 | 2.62 | | -0.47 | 0.055 | 2.62 | -0.47 | 0.055 | 193.6 | 2.63 | | | -0.43 | 0.048 | 2.63 | -0.43 | 0.048 | |
| 2.700 | 32.6 | 2.38 | 0.20 | 401.5 | 0.0 | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 240.9 | 0.0 | | | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | |
| 2.750 | 32.7 | 2.14 | 0.04 | 75.8 | 2.12 | | -0.02 | 0.012 | 2.12 | -0.02 | 0.012 | 45.5 | 2.12 | | | -0.02 | 0.010 | 2.12 | -0.02 | 0.010 | |
| 2.800 | 32.8 | 1.90 | 0.28 | 639.8 | 0.89 | | -6.51 | 0.531 | 0.89 | -6.51 | 0.531 | 383.9 | .98 | | | -1.41 | 0.166 | 1.58 | -1.41 | 0.166 | |

[DX 708, P 34]

34

25 mph
15 mu

E-1294

[DX 708, P 34]

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 0.0 | 36.67 | 0.11 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | 0.0 | 36.67 | 0.00 | 0.000 | 36.67 | 0.00 | 0.000 | | | |
| 0.050 | 1.8 | 36.46 | 0.23 | 663.6 | 20.84 | -9.10 | 0.162 | 29.84 | -9.10 | 0.162 | 398.2 | 32.50 | -4.35 | 0.109 | 32.50 | -4.35 | 0.109 | | | |
| 0.100 | 3.6 | 36.12 | 0.18 | 1180.4 | 0.61 | -27.21 | 0.983 | 0.61 | -27.21 | 0.983 | 519.2 | 22.58 | -8.16 | 0.375 | 22.58 | -8.16 | 0.375 | | | |
| 0.150 | 5.4 | 35.74 | 0.16 | 1221.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 527.6 | 6.61 | -9.90 | 0.816 | 6.61 | -9.90 | 0.816 | | | |
| 0.200 | 7.2 | 35.59 | 0.16 | 230.7 | 0.00 | 0.12 | 1.000 | 0.00 | 0.12 | 1.000 | 138.4 | 0.04 | 0.60 | 0.999 | 0.04 | 0.60 | 0.999 | | | |
| 0.250 | 9.0 | 35.33 | 0.17 | 224.0 | 5.13 | 1.06 | 0.855 | 5.13 | 1.06 | 0.855 | 134.4 | 3.03 | 0.96 | 0.892 | 3.83 | 0.96 | 0.892 | | | |
| 0.300 | 10.8 | 35.07 | 0.16 | 215.7 | 0.04 | 0.77 | 0.999 | 0.04 | 0.77 | 0.999 | 129.4 | 0.79 | 0.82 | 0.978 | 0.79 | 0.82 | 0.978 | | | |
| 0.350 | 12.5 | 34.80 | 0.17 | 256.5 | 5.60 | 0.43 | 0.839 | 5.60 | 0.43 | 0.839 | 153.9 | 4.55 | 0.42 | 0.869 | 4.55 | 0.42 | 0.869 | | | |
| 0.400 | 14.2 | 34.54 | 0.16 | 201.8 | 0.14 | 1.36 | 0.996 | 0.14 | 1.36 | 0.996 | 121.1 | 1.59 | 1.13 | 0.954 | 1.59 | 1.13 | 0.954 | | | |
| 0.450 | 16.0 | 34.27 | 0.18 | 290.6 | 5.93 | -0.35 | 0.827 | 5.93 | -0.35 | 0.827 | 174.4 | 5.46 | -0.04 | 0.841 | 5.46 | -0.04 | 0.841 | | | |
| 0.500 | 17.7 | 34.00 | 0.16 | 202.1 | 0.15 | 1.43 | 0.995 | 0.15 | 1.43 | 0.995 | 121.2 | 2.32 | 1.25 | 0.932 | 2.32 | 1.25 | 0.932 | | | |
| 0.550 | 19.4 | 33.72 | 0.18 | 290.7 | 6.03 | -0.32 | 0.821 | 6.03 | -0.32 | 0.821 | 174.4 | 6.42 | 0.13 | 0.810 | 6.42 | 0.13 | 0.810 | | | |
| 0.600 | 21.0 | 33.45 | 0.16 | 202.2 | 0.14 | 1.36 | 0.996 | 0.14 | 1.36 | 0.996 | 121.3 | 3.57 | 1.44 | 0.893 | 3.57 | 1.44 | 0.893 | | | |
| 0.650 | 22.7 | 33.17 | 0.18 | 290.7 | 5.84 | -0.46 | 0.824 | 5.84 | -0.46 | 0.824 | 174.4 | 8.02 | 0.37 | 0.758 | 8.02 | 0.37 | 0.758 | | | |
| 0.700 | 24.4 | 32.90 | 0.16 | 216.9 | 0.04 | 0.77 | 0.999 | 0.04 | 0.77 | 0.999 | 130.1 | 5.06 | 1.40 | 0.846 | 5.06 | 1.40 | 0.846 | | | |
| 0.750 | 26.0 | 32.62 | 0.18 | 238.9 | 5.69 | 0.82 | 0.826 | 5.69 | 0.82 | 0.826 | 143.3 | 10.03 | 1.51 | 0.692 | 10.03 | 1.51 | 0.692 | | | |
| 0.800 | 27.6 | 32.35 | 0.16 | 264.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 158.9 | 6.78 | 0.77 | 0.790 | 6.78 | 0.77 | 0.790 | | | |
| 0.850 | 29.2 | 32.07 | 0.17 | 463.7 | 1.90 | -6.31 | 0.941 | 1.90 | -6.31 | 0.941 | 278.2 | 10.03 | -2.35 | 0.687 | 10.03 | -2.35 | 0.687 | | | |
| 0.900 | 30.8 | 31.81 | 0.17 | 152.9 | 0.50 | 2.34 | 0.984 | 0.50 | 2.34 | 0.984 | 91 7 | 9.07 | 2.89 | 0.715 | 9.07 | 2.89 | 0.715 | | | |
| 0.950 | 32.4 | 31.54 | 0.16 | 285.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 171.3 | 8.61 | 0.56 | 0.727 | 8.61 | 0.56 | 0.727 | | | |
| 1.000 | 34.0 | 31.27 | 0.16 | 406.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 243.6 | 9.09 | -1.49 | 0.709 | 9.09 | -1.49 | 0.709 | | | |
| 1.050 | 35.5 | 31.01 | 0.16 | 500.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 300.4 | 9.48 | -3.08 | 0.694 | 9.48 | -3.08 | 0.694 | | | |
| 1.100 | 37.1 | 30.74 | 0.16 | 538.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 322.9 | 9.81 | -3.70 | 0.681 | 9.81 | -3.70 | 0.681 | | | |
| 1.150 | 38.6 | 30.48 | 0.17 | 355.3 | 0.48 | -3.46 | 0.984 | 0.48 | -3.46 | 0.984 | 213.2 | 10.21 | -0.52 | 0.665 | 10.21 | -0.52 | 0.665 | | | |
| 1.200 | 40.1 | 30.21 | 0.17 | 154.5 | 0.69 | 2.38 | 0.977 | 0.69 | 2.38 | 0.977 | 92.7 | 9.85 | 2.90 | 0.674 | 9.85 | 2.90 | 0.674 | | | |
| 1.250 | 41.5 | 29.94 | 0.17 | 207.3 | 0.05 | 0.85 | 0.998 | 0.05 | 0.85 | 0.998 | 124.4 | 8.64 | 1.89 | 0.711 | 8.64 | 1.89 | 0.711 | | | |
| 1.300 | 43.1 | 29.67 | 0.16 | 410.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 246.3 | 7.61 | -1.70 | 0.744 | 7.61 | -1.70 | 0.744 | | | |
| 1.350 | 44.6 | 29.40 | 0.17 | 382.6 | 2.42 | -3.67 | 0.918 | 2.42 | -3.67 | 0.918 | 229.6 | 10.37 | -0.93 | 0.647 | 10.37 | -0.93 | 0.647 | | | |
| 1.400 | 46.1 | 29.13 | 0.17 | 143.3 | 0.82 | 3.01 | 0.972 | 0.82 | 3.01 | 0.972 | 86.0 | 9.86 | 3.15 | 0.662 | 9.86 | 3.15 | 0.662 | | | |
| 1.450 | 47.5 | 28.86 | 0.17 | 210.3 | 0.08 | 1.03 | 0.997 | 0.08 | 1.03 | 0.997 | 126.2 | 9.08 | 1.93 | 0.685 | 9.08 | 1.93 | 0.685 | | | |
| 1.500 | 48.9 | 28.58 | 0.17 | 294.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 176.8 | 8.44 | 0.43 | 0.705 | 8.44 | 0.43 | 0.705 | | | |
| 1.550 | 50.4 | 28.30 | 0.17 | 455.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 273.3 | 8.41 | -2.33 | 0.703 | 8.41 | -2.33 | 0.703 | | | |
| 1.600 | 51.8 | 28.03 | 0.18 | 388.9 | 2.08 | -3.72 | 0.926 | 2.08 | -3.72 | 0.926 | 233.3 | 10.73 | -0.93 | 0.617 | 10.73 | -0.93 | 0.617 | | | |
| 1.650 | 53.2 | 27.75 | 0.17 | 157.6 | 0.60 | 2.63 | 0.978 | 0.60 | 2.63 | 0.978 | 94.6 | 9.56 | 2.93 | 0.656 | 9.56 | 2.93 | 0.656 | | | |
| 1.700 | 54.5 | 27.48 | 0.17 | 231.1 | 0.01 | 0.38 | 1.000 | 0.01 | 0.38 | 1.000 | 138.7 | 8.63 | 1.58 | 0.696 | 8.63 | 1.58 | 0.696 | | | |
| 1.750 | 55.9 | 27.20 | 0.17 | 338.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 202.9 | 8.63 | -0.26 | 0.683 | 8.63 | -0.26 | 0.683 | | | |
| 1.800 | 57.3 | 26.93 | 0.17 | 474.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 284.5 | 9.38 | -2.50 | 0.652 | 9.38 | -2.50 | 0.652 | | | |
| 1.850 | 58.6 | 26.66 | 0.17 | 562.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 337.4 | 9.87 | -3.95 | 0.630 | 9.87 | -3.95 | 0.630 | | | |
| 1.900 | 59.9 | 26.39 | 0.17 | 424.7 | 0.38 | -5.33 | 0.986 | 0.38 | -5.33 | 0.986 | 254.8 | 10.28 | -1.53 | 0.611 | 10.28 | -1.53 | 0.611 | | | |
| 1.950 | 61.2 | 26.12 | 0.16 | 170.4 | 0.31 | 1.89 | 0.988 | 0.31 | 1.89 | 0.988 | 102.2 | 7.96 | 2.59 | 0.695 | 7.96 | 2.59 | 0.695 | | | |
| 2.000 | 62.5 | 25.85 | 0.16 | 328.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 197.0 | 8.51 | -0.07 | 0.671 | 8.51 | -0.07 | 0.671 | | | |
| 2.050 | 63.8 | 25.58 | 0.17 | 476.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 286.1 | 9.17 | -2.52 | 0.642 | 9.17 | -2.52 | 0.642 | | | |
| 2.100 | 65.1 | 25.32 | 0.17 | 581.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 348.7 | 9.49 | -4.26 | 0.625 | 9.49 | -4.26 | 0.625 | | | |
| 2.150 | 66.4 | 25.05 | 0.17 | 195.7 | 1.23 | 1.30 | 0.951 | 1.23 | 1.30 | 0.951 | 117.4 | 10.43 | 2.49 | 0.534 | 10.43 | 2.49 | 0.534 | | | |
| 2.200 | 67.6 | 24.78 | 0.16 | 213.8 | 0.03 | 0.60 | 0.999 | 0.03 | 0.60 | 0.999 | 128.3 | 8.05 | 1.91 | 0.675 | 8.05 | 1.91 | 0.675 | | | |
| 2.250 | 68.8 | 24.51 | 0.17 | 409.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 245.7 | 9.00 | -2.71 | 0.633 | 9.00 | -2.71 | 0.633 | | | |
| 2.300 | 70.1 | 24.24 | 0.17 | 541.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 324.7 | 10.14 | -3.44 | 0.592 | 10.14 | -3.44 | 0.592 | | | |
| 2.350 | 71.3 | 23.97 | 0.17 | 235.4 | 0.92 | 0.29 | 0.962 | 0.92 | 0.29 | 0.962 | 141.2 | 10.38 | 1.85 | 0.557 | 10.38 | 1.85 | 0.557 | | | |
| 2.400 | 72.5 | 23.69 | 0.17 | 172.0 | 0.35 | 2.05 | 0.985 | 0.35 | 2.05 | 0.985 | 103.2 | 9.31 | 2.82 | 0.607 | 9.31 | 2.82 | 0.607 | | | |
| 2.450 | 73.6 | 23.42 | 0.17 | 301.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 181.1 | 7.93 | 0.43 | 0.652 | 7.93 | 0.43 | 0.652 | | | |
| 2.500 | 74.8 | 23.14 | 0.17 | 597.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 358.3 | 9.46 | -4.45 | 0.591 | 9.46 | -4.45 | 0.591 | | | |
| 2.550 | 75.9 | 22.87 | 0.18 | 209.4 | 1.47 | 1.31 | 0.936 | 1.47 | 1.31 | 0.936 | 125.6 | 10.51 | 2.37 | 0.541 | 10.51 | 2.37 | 0.541 | | | |
| 2.600 | 77.1 | 22.59 | 0.17 | 176.2 | 0.34 | 2.05 | 0.985 | 0.34 | 2.05 | 0.985 | 105.7 | 9.65 | 2.84 | 0.573 | 9.65 | 2.84 | 0.573 | | | |
| 2.650 | 78.2 | 22.31 | 0.17 | 245.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 147.4 | 8.83 | 1.55 | 0.604 | 8.83 | 1.55 | 0.604 | | | |
| 2.700 | 79.3 | 22.04 | 0.17 | 321.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 192.7 | 8.43 | 0.21 | 0.618 | 8.43 | 0.21 | 0.618 | | | |
| 2.750 | 80.4 | 21.76 | 0.17 | 514.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 308.9 | 8.71 | -3.06 | 0.600 | 8.71 | -3.06 | 0.600 | | | |
| 2.800 | 81.5 | 21.48 | 0.18 | 301.1 | 1.65 | -1.35 | 0.923 | 1.65 | -1.35 | 0.923 | 180.7 | 10.81 | 0.92 | 0.497 | 10.81 | 0.92 | 0.497 | | | |
| 2.850 | 82.6 | 21.21 | 0.17 | 179.1 | 0.27 | 1.81 | 0.987 | 0.27 | 1.81 | 0.987 | 107.5 | 9.23 | 2.81 | 0.565 | 9.23 | 2.81 | 0.565 | | | |
| 2.900 | 83.6 | 20.93 | 0.17 | 263.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 157.8 | 9.03 | 1.36 | 0.569 | 9.03 | 1.36 | 0.569 | | | |
| 2.950 | 84.6 | 20.66 | 0.17 | 328.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 196.9 | 9.03 | 0.26 | 0.563 | 9.03 | 0.26 | 0.563 | | | |
| 3.000 | 85.7 | 20.38 | 0.17 | 416.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 250.1 | 8.65 | -1.30 | 0.576 | 8.65 | -1.30 | 0.576 | | | |
| 3.050 | 86.7 | 20.11 | 0.17 | 554.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 332.6 | 9.32 | -3.55 | 0.537 | 9.32 | -3.55 | 0.537 | | | |

[DX 708, p 35]

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3.100 | 88.7 | 19.57 | 0.17 | 151.5 | 0.57 | 2.53 | 0.971 | 0.57 | 2.53 | 0.971 | 90.9 | 9.57 | 3.46 | 0.511 | 9.57 | 3.46 | 0.511 |
| | 3.200 | 89.6 | 19.29 | 0.17 | 272.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 143.5 | 8.64 | 1.25 | 0.552 | 8.64 | 1.25 | 0.552 |
| | 3.250 | 90.6 | 19.02 | 0.17 | 334.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 224.5 | 8.58 | -0.49 | 0.549 | 8.58 | -0.49 | 0.549 |
| | 3.300 | 91.5 | 18.74 | 0.17 | 466.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 297.6 | 8.81 | -2.53 | 0.530 | 8.81 | -2.53 | 0.530 |
| | 3.350 | 92.5 | 19.47 | 0.17 | 567.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 340.3 | 10.27 | -3.49 | 0.444 | 10.27 | -3.49 | 0.444 |
| | 3.400 | 93.4 | 18.19 | 0.18 | 147.1 | 0.70 | 2.83 | 0.961 | 0.70 | 2.83 | 0.961 | 88.2 | 9.80 | 3.67 | 0.461 | 9.80 | 3.67 | 0.461 |
| | 3.450 | 94.3 | 17.91 | 0.17 | 256.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 153.7 | 8.78 | 1.65 | 0.510 | 8.78 | 1.65 | 0.510 |
| | 3.500 | 95.2 | 17.63 | 0.17 | 338.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 203.2 | 8.66 | 0.23 | 0.509 | 8.66 | 0.23 | 0.509 |
| | 3.550 | 96.0 | 17.35 | 0.17 | 425.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 255.2 | 8.43 | -1.28 | 0.514 | 8.43 | -1.28 | 0.514 |
| | 3.600 | 96.9 | 17.07 | 0.18 | 630.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 378.0 | 9.80 | -4.54 | 0.426 | 9.80 | -4.54 | 0.426 |
| | 3.650 | 97.8 | 16.79 | 0.18 | 213.2 | 1.04 | 1.16 | 0.938 | 1.04 | 1.16 | 0.938 | 127.9 | 10.51 | 2.78 | 0.374 | 10.51 | 2.78 | 0.374 |
| | 3.700 | 98.6 | 16.51 | 0.17 | 206.9 | 0.09 | 1.08 | 0.995 | 0.09 | 1.08 | 0.995 | 124.2 | 9.00 | 2.65 | 0.455 | 9.00 | 2.65 | 0.455 |
| | 3.750 | 99.4 | 16.22 | 0.17 | 330.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 198.1 | 8.47 | 0.46 | 0.478 | 8.47 | 0.46 | 0.478 |
| | 3.800 | 100.2 | 15.94 | 0.17 | 455.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 273.5 | 8.73 | -1.63 | 0.452 | 8.73 | -1.63 | 0.452 |
| | 3.850 | 101.0 | 15.66 | 0.18 | 578.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 347.2 | 9.50 | -3.56 | 0.393 | 9.50 | -3.56 | 0.393 |
| | 3.900 | 101.8 | 15.37 | 0.18 | 569.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 341.6 | 10.10 | -3.25 | 0.343 | 10.10 | -3.25 | 0.343 |
| | 3.950 | 102.5 | 15.09 | 0.18 | 514.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 308.7 | 10.91 | -2.12 | 0.277 | 10.91 | -2.12 | 0.277 |
| | 4.000 | 103.3 | 14.81 | 0.18 | 175.7 | 0.38 | 1.92 | 0.974 | 0.38 | 1.92 | 0.974 | 105.4 | 10.22 | 3.61 | 0.310 | 10.22 | 3.61 | 0.310 |
| | 4.050 | 104.0 | 14.52 | 0.18 | 210.3 | 0.05 | 0.81 | 0.997 | 0.05 | 0.81 | 0.997 | 126.2 | 9.70 | 2.95 | 0.332 | 9.70 | 2.95 | 0.332 |
| | 4.100 | 104.7 | 14.24 | 0.18 | 243.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 149.9 | 9.33 | 2.23 | 0.345 | 9.33 | 2.23 | 0.345 |
| | 4.150 | 105.4 | 13.96 | 0.18 | 291.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 174.8 | 9.50 | 1.59 | 0.319 | 9.50 | 1.59 | 0.319 |
| | 4.200 | 106.1 | 13.67 | 0.17 | 347.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 208.6 | 8.62 | 0.47 | 0.370 | 8.62 | 0.47 | 0.370 |
| | 4.250 | 106.8 | 13.38 | 0.18 | 419.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 251.5 | 9.19 | -0.59 | 0.313 | 9.19 | -0.59 | 0.313 |
| | 4.300 | 107.5 | 13.09 | 0.18 | 524.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 314.5 | 9.13 | -2.37 | 0.303 | 9.13 | -2.37 | 0.303 |
| | 4.350 | 108.1 | 12.80 | 0.18 | 618.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 371.0 | 10.23 | -3.69 | 0.231 | 10.23 | -3.69 | 0.231 |
| | 4.400 | 108.7 | 12.51 | 0.18 | 501.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 300.7 | 10.98 | -1.76 | 0.123 | 10.98 | -1.76 | 0.123 |
| | 4.450 | 109.4 | 12.22 | 0.18 | 183.0 | 0.32 | 1.77 | 0.974 | 0.32 | 1.77 | 0.974 | 109.8 | 10.68 | 3.76 | 0.126 | 10.68 | 3.76 | 0.126 |
| | 4.500 | 110.0 | 11.93 | 0.17 | 273.5 | 0.02 | 0.53 | 0.998 | 0.02 | 0.53 | 0.998 | 134.1 | 10.14 | 3.24 | 0.150 | 10.14 | 3.24 | 0.150 |
| | 4.550 | 110.6 | 11.64 | 0.18 | 236.5 | 0.00 | 0.17 | 1.000 | 0.00 | 0.17 | 1.000 | 141.9 | 10.08 | 2.94 | 0.134 | 10.08 | 2.94 | 0.134 |
| | 4.600 | 111.1 | 11.35 | 0.18 | 230.4 | 0.01 | 0.36 | 0.999 | 0.01 | 0.36 | 0.999 | 138.2 | 10.07 | 2.69 | 0.113 | 10.07 | 2.69 | 0.113 |
| | 4.650 | 111.7 | 11.07 | 0.16 | 213.8 | 0.05 | 0.86 | 0.995 | 0.05 | 0.86 | 0.995 | 128.3 | 10.27 | 1.53 | 0.073 | 10.27 | 1.53 | 0.073 |
| | 4.700 | 112.2 | 10.80 | 0.14 | 188.9 | 0.27 | 1.67 | 0.975 | 0.27 | 1.67 | 0.975 | 113.3 | 10.26 | 0.69 | 0.050 | 10.26 | 0.69 | 0.050 |
| | 4.750 | 112.8 | 10.53 | 0.15 | 406.4 | 0.11 | -4.64 | 0.990 | 0.11 | -4.64 | 0.990 | 243.8 | 9.91 | -2.48 | 0.099 | 9.91 | -2.48 | 0.099 |
| | 4.800 | 113.3 | 10.26 | 0.18 | 559.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 335.5 | 9.17 | -3.08 | 0.107 | 9.17 | -3.08 | 0.107 |
| | 4.850 | 113.8 | 9.99 | 0.16 | 383.1 | 0.00 | -4.06 | 1.000 | 0.00 | -4.06 | 1.000 | 229.9 | 9.30 | -1.53 | 0.069 | 9.30 | -1.53 | 0.069 |
| | 4.900 | 114.3 | 9.74 | 0.17 | 441.6 | 0.21 | -5.67 | 0.978 | 0.21 | -5.67 | 0.978 | 264.9 | 8.89 | -1.65 | 0.068 | 8.89 | -1.65 | 0.068 |
| | 4.950 | 114.8 | 9.46 | 0.18 | 424.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 254.8 | 6.88 | -0.50 | 0.273 | 6.88 | -0.50 | 0.273 |
| | 5.000 | 115.2 | 9.20 | 0.16 | 347.7 | 1.18 | -2.57 | 0.872 | 1.18 | -2.57 | 0.872 | 208.6 | 8.62 | -1.22 | 0.063 | 8.62 | -1.22 | 0.063 |
| | 5.050 | 115.7 | 8.91 | 0.17 | 204.1 | 0.07 | 1.00 | 0.992 | 0.07 | 1.00 | 0.992 | 122.4 | 8.08 | 2.63 | 0.093 | 8.08 | 2.63 | 0.093 |
| | 5.100 | 116.1 | 8.65 | 0.18 | 495.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 291.4 | 6.54 | -1.47 | 0.244 | 6.54 | -1.47 | 0.244 |
| | 5.150 | 116.5 | 8.37 | 0.15 | 291.4 | 1.28 | -0.89 | 0.847 | 1.28 | -0.89 | 0.847 | 174.8 | 7.96 | -0.93 | 0.052 | 7.96 | -0.93 | 0.052 |
| | 5.200 | 117.0 | 8.11 | 0.18 | 234.4 | 0.00 | 0.07 | 1.000 | 0.00 | 0.07 | 1.000 | 140.6 | 6.77 | 3.06 | 0.165 | 6.77 | 3.06 | 0.165 |
| | 5.250 | 117.4 | 7.85 | 0.18 | 583.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 349.9 | 6.18 | -3.08 | 0.212 | 6.18 | -3.08 | 0.212 |
| | 5.300 | 117.7 | 7.58 | 0.14 | 192.3 | 1.39 | 2.09 | 0.817 | 1.39 | 2.09 | 0.817 | 115.4 | 7.32 | -0.42 | 0.034 | 7.32 | -0.42 | 0.034 |
| | 5.350 | 118.1 | 7.31 | 0.18 | 303.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 184.9 | 5.24 | 1.43 | 0.283 | 5.24 | 1.43 | 0.283 |
| | 5.400 | 118.5 | 7.05 | 0.18 | 495.7 | 0.20 | -7.24 | 0.971 | 0.20 | -7.24 | 0.971 | 297.4 | 6.24 | -1.80 | 0.114 | 6.24 | -1.80 | 0.114 |
| | 5.450 | 118.8 | 6.76 | 0.15 | 158.3 | 0.54 | 2.68 | 0.920 | 0.54 | 2.68 | 0.920 | 95.0 | 6.44 | 1.13 | 0.048 | 6.44 | 1.13 | 0.048 |
| | 5.500 | 119.1 | 6.50 | 0.18 | 455.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 279.4 | 4.26 | -1.46 | 0.345 | 4.26 | -1.46 | 0.345 |
| | 5.550 | 119.5 | 6.24 | 0.14 | 87.9 | 3.22 | 6.69 | 0.483 | 3.22 | 6.69 | 0.483 | 52.8 | 6.13 | -0.01 | 0.017 | 6.13 | -0.01 | 0.017 |
| | 5.600 | 119.8 | 5.97 | 0.20 | 530.9 | 2.14 | -6.69 | 0.642 | 2.14 | -6.69 | 0.642 | 318.6 | 4.10 | -2.48 | 0.313 | 4.10 | -2.48 | 0.313 |
| | 5.650 | 120.1 | 5.70 | 0.14 | 100.3 | 2.53 | 6.05 | 0.556 | 2.53 | 6.05 | 0.556 | 60.2 | 5.59 | 0.00 | 0.019 | 5.59 | 0.00 | 0.019 |
| | 5.700 | 120.3 | 5.46 | 0.21 | 616.3 | 2.51 | -8.66 | 0.541 | 2.51 | -8.66 | 0.541 | 369.8 | 3.95 | -3.81 | 0.276 | 3.95 | -3.81 | 0.276 |
| | 5.750 | 120.6 | 5.18 | 0.14 | 122.1 | 1.55 | 4.78 | 0.700 | 1.55 | 4.78 | 0.700 | 73.3 | 5.04 | 0.21 | 0.027 | 5.04 | 0.21 | 0.027 |
| | 5.800 | 120.9 | 4.95 | 0.22 | 567.6 | 3.46 | -6.20 | 0.296 | 3.48 | -6.20 | 0.296 | 340.5 | 4.13 | -2.63 | 0.167 | 4.13 | -2.63 | 0.167 |
| | 5.850 | 121.1 | 4.66 | 0.18 | 149.2 | 0.77 | 3.36 | 0.835 | 0.77 | 3.36 | 0.835 | 89.5 | 4.24 | 3.43 | 0.089 | 4.24 | 3.43 | 0.089 |
| | 5.900 | 121.3 | 4.46 | 0.23 | 455.2 | 3.80 | -2.39 | 0.147 | 3.80 | -2.39 | 0.147 | 273.1 | 3.99 | -1.23 | 0.105 | 3.99 | -1.28 | 0.105 |
| | 5.950 | 121.5 | 4.17 | 0.17 | 194.0 | 0.15 | 1.45 | 0.965 | 0.15 | 1.45 | 0.965 | 116.4 | 1.84 | 2.62 | 0.558 | 1.84 | 2.62 | 0.558 |
| | 6.000 | 121.7 | 3.96 | 0.16 | 308.0 | 3.67 | -0.92 | 0.075 | 3.67 | -0.92 | 0.075 | 184.8 | 3.73 | -0.71 | 0.060 | 3.73 | -0.71 | 0.060 |
| | 6.050 | 121.9 | 3.67 | 0.16 | 253.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 151.9 | 0.53 | 0.71 | 0.857 | 0.53 | 0.71 | 0.857 |
| | 6.100 | 122.1 | 3.46 | 0.10 | 178.6 | 3.33 | -0.47 | 0.038 | 3.33 | -0.47 | 0.038 | 107.2 | 1.35 | -0.40 | 0.031 | 3.35 | -0.40 | 0.031 |
| | 6.150 | 122.3 | 3.18 | 0.15 | 330.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 198.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 |
| | 6.200 | 122.6 | 2.96 | 0.05 | 91.4 | 2.00 | -0.17 | 0.018 | 2.00 | -0.17 | 0.018 | 55.0 | 2.00 | -0.17 | 0.018 | 2.00 | -0.17 | 0.018 |

25 mph
.15 mu
continued

35

E-1295

[DX 708, p 35]

[DX 708, p 40]

40

1

20 mph
.15 mu

[DX 708, p 40]

E-1296

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3000 | 5.31 | 7.97 | 18.00 | 98.65 | .030 | .020 | .030 | 0.51 | 0.34 | 250.0 | 150.0 | 0.92 | 700. | .344 | 20.0 | | | | | | |
| 0.000 | 0.0 | 29.33 | 0.01 | 0.0 | 29.33 | 0.00 | 0.000 | 29.33 | 0.00 | 0.000 | 0.0 | 29.33 | 0.00 | 0.000 | 29.33 | 0.00 | 0.000 | | | | |
| 0.050 | 1.5 | 27.12 | 0.23 | 663.6 | 22.98 | -9.21 | 0.211 | 22.98 | -9.21 | 0.211 | 399.2 | 25.60 | -4.06 | 0.121 | 25.60 | -4.06 | 0.121 | | | | |
| 0.100 | 2.9 | 26.79 | 0.17 | 1160.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 519.2 | 15.50 | -8.43 | 0.452 | 15.50 | -8.43 | 0.452 | | | | |
| 0.150 | 4.3 | 28.53 | 0.16 | 512.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 307.7 | 2.36 | -3.90 | 0.917 | 2.36 | -3.90 | 0.917 | | | | |
| 0.200 | 5.8 | 28.23 | 0.16 | 96.9 | 2.00 | 4.26 | 0.929 | 2.00 | 4.26 | 0.929 | 58.1 | 3.19 | 3.24 | 0.807 | 3.19 | 3.24 | 0.807 | | | | |
| 0.250 | 7.2 | 28.01 | 0.17 | 553.5 | 3.74 | -8.43 | 0.867 | 3.74 | -8.43 | 0.867 | 332.1 | 5.15 | -4.48 | 0.816 | 5.15 | -4.48 | 0.816 | | | | |
| 0.300 | 8.6 | 27.75 | 0.16 | 110.2 | 1.42 | 3.79 | 0.949 | 1.42 | 3.79 | 0.949 | 70.9 | 4.64 | 2.91 | 0.833 | 4.64 | 2.91 | 0.833 | | | | |
| 0.350 | 9.9 | 27.47 | 0.13 | 464.3 | 5.83 | -5.29 | 0.788 | 5.83 | -5.29 | 0.788 | 278.6 | 8.11 | -2.69 | 0.705 | 8.11 | -2.69 | 0.705 | | | | |
| 0.400 | 11.3 | 27.20 | 0.17 | 145.0 | 1.70 | 3.26 | 0.937 | 1.70 | 3.26 | 0.937 | 87.0 | 6.68 | 2.67 | 0.754 | 6.68 | 2.67 | 0.754 | | | | |
| 0.450 | 12.7 | 26.90 | 0.19 | 576.6 | 6.84 | -8.16 | 0.746 | 6.84 | -8.16 | 0.746 | 346.0 | 10.77 | -4.28 | 0.500 | 10.77 | -4.28 | 0.500 | | | | |
| 0.500 | 14.0 | 26.62 | 0.17 | 156.7 | 1.15 | 2.92 | 0.957 | 1.15 | 2.92 | 0.957 | 94.0 | 8.76 | 2.76 | 0.671 | 8.76 | 2.76 | 0.671 | | | | |
| 0.550 | 15.3 | 26.34 | 0.17 | 309.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 185.4 | 9.46 | 0.27 | 0.641 | 9.46 | 0.27 | 0.641 | | | | |
| 0.600 | 16.6 | 26.06 | 0.17 | 349.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 209.5 | 8.82 | -0.43 | 0.662 | 8.82 | -0.43 | 0.662 | | | | |
| 0.650 | 17.9 | 25.78 | 0.17 | 450.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 270.2 | 9.77 | -2.00 | 0.621 | 9.77 | -2.00 | 0.621 | | | | |
| 0.700 | 19.2 | 25.51 | 0.17 | 464.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 278.8 | 9.56 | -2.22 | 0.625 | 9.56 | -2.22 | 0.625 | | | | |
| 0.750 | 20.5 | 25.23 | 0.17 | 478.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 287.0 | 9.41 | -2.43 | 0.627 | 9.41 | -2.43 | 0.627 | | | | |
| 0.800 | 21.7 | 24.9[illegible] | 0.17 | 467.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 280.6 | 9.31 | -2.23 | 0.627 | 9.31 | -2.23 | 0.627 | | | | |
| 0.850 | 23.0 | 24.[illegible] | 0.17 | 222.5 | 0.84 | 0.52 | 0.965 | 0.84 | 0.52 | 0.965 | 133.5 | 10.55 | 2.15 | 0.573 | 10.55 | 2.15 | 0.573 | | | | |
| 0.900 | 24.2 | 24.4[illegible] | 0.16 | 286.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 171.8 | 7.92 | 0.73 | 0.676 | 7.92 | 0.73 | 0.676 | | | | |
| 0.950 | 25.4 | 24.14 | 0.17 | 522.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 313.5 | 9.96 | -3.09 | 0.587 | 9.96 | -3.09 | 0.587 | | | | |
| 1.000 | 26.6 | 23.87 | 0.17 | 541.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 324.7 | 10.11 | -3.40 | 0.576 | 10.11 | -3.40 | 0.576 | | | | |
| 1.050 | 27.8 | 23.61 | 0.17 | 521.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 313.2 | 10.09 | -3.09 | 0.573 | 10.09 | -3.09 | 0.573 | | | | |
| 1.100 | 29.0 | 23.34 | 0.17 | 523.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 313.8 | 9.53 | -3.18 | 0.592 | 9.53 | -3.18 | 0.592 | | | | |
| 1.150 | 30.1 | 23.07 | 0.17 | 197.2 | 1.21 | 1.22 | 0.948 | 1.21 | 1.22 | 0.948 | 118.3 | 10.70 | 2.57 | 0.536 | 10.70 | 2.57 | 0.536 | | | | |
| 1.200 | 31.3 | 22.80 | 0.17 | 472.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 283.7 | 10.48 | -2.18 | 0.540 | 10.48 | -2.18 | 0.540 | | | | |
| 1.250 | 32.4 | 22.53 | 0.17 | 144.9 | 0.68 | 2.75 | 0.970 | 0.68 | 2.75 | 0.970 | 87.0 | 10.07 | 3.41 | 0.553 | 10.07 | 3.41 | 0.553 | | | | |
| 1.300 | 33.5 | 22.26 | 0.17 | 204.1 | 0.08 | 1.01 | 0.996 | 0.08 | 1.01 | 0.996 | 122.4 | 10.12 | 2.42 | 0.565 | 10.12 | 2.42 | 0.565 | | | | |
| 1.350 | 34.6 | 21.98 | 0.17 | 215.3 | 0.04 | 0.76 | 0.995 | 0.04 | 0.76 | 0.998 | 129.2 | 9.57 | 2.17 | 0.575 | 9.57 | 2.17 | 0.575 | | | | |
| 1.400 | 35.7 | 21.71 | 0.17 | 252.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 151.3 | 9.53 | 1.56 | 0.561 | 9.53 | 1.56 | 0.561 | | | | |
| 1.450 | 36.8 | 21.43 | 0.17 | 267.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 160.4 | 9.48 | 1.31 | 0.558 | 9.48 | 1.31 | 0.558 | | | | |
| 1.500 | 37.9 | 21.15 | 0.17 | 273.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 164.3 | 9.69 | 1.25 | 0.542 | 9.69 | 1.25 | 0.542 | | | | |
| 1.550 | 38.9 | 20.87 | 0.17 | 287.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 172.8 | 9.01 | 0.93 | 0.560 | 9.01 | 0.93 | 0.560 | | | | |
| 1.600 | 40.0 | 20.59 | 0.17 | 313.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 188.3 | 9.43 | 0.57 | 0.542 | 9.43 | 0.57 | 0.542 | | | | |
| 1.650 | 41.0 | 20.31 | 0.17 | 322.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 193.3 | 9.36 | 0.43 | 0.539 | 9.36 | 0.43 | 0.539 | | | | |
| 1.700 | 42.0 | 20.03 | 0.17 | 331.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 198.8 | 9.53 | 0.32 | 0.524 | 9.53 | 0.32 | 0.524 | | | | |
| 1.750 | 43.0 | 19.75 | 0.17 | 341.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 204.8 | 9.15 | 0.11 | 0.537 | 9.15 | 0.11 | 0.537 | | | | |
| 1.800 | 44.0 | 19.47 | 0.17 | 390.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 234.4 | 9.34 | -0.69 | 0.520 | 9.34 | -0.69 | 0.520 | | | | |
| 1.850 | 44.9 | 19.19 | 0.17 | 412.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 247.4 | 9.60 | -1.00 | 0.499 | 9.60 | -1.00 | 0.499 | | | | |
| 1.900 | 45.9 | 18.91 | 0.17 | 419.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 251.8 | 9.43 | -1.14 | 0.501 | 9.43 | -1.14 | 0.501 | | | | |
| 1.950 | 46.8 | 18.63 | 0.17 | 448.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 269.3 | 9.50 | -1.66 | 0.470 | 9.50 | -1.66 | 0.470 | | | | |
| 2.000 | 47.7 | 18.36 | 0.17 | 482.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 289.3 | 9.64 | -2.13 | 0.475 | 9.64 | -2.13 | 0.475 | | | | |
| 2.050 | 48.7 | 18.08 | 0.17 | 519.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 312.0 | 9.77 | -2.74 | 0.459 | 9.77 | -2.74 | 0.459 | | | | |
| 2.100 | 49.6 | 17.81 | 0.17 | 534.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 320.6 | 10.18 | -2.99 | 0.428 | 10.18 | -2.99 | 0.428 | | | | |
| 2.150 | 50.4 | 17.53 | 0.17 | 578.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 347.2 | 9.89 | -3.67 | 0.436 | 9.89 | -3.67 | 0.436 | | | | |
| 2.200 | 51.3 | 17.25 | 0.17 | 472.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 283.2 | 10.92 | -1.64 | 0.357 | 10.92 | -1.64 | 0.357 | | | | |
| 2.250 | 52.2 | 16.97 | 0.18 | 531.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 319.0 | 10.80 | -2.66 | 0.354 | 10.80 | -2.66 | 0.354 | | | | |
| 2.300 | 53.0 | 16.70 | 0.18 | 209.5 | 0.52 | 0.95 | 0.969 | 0.52 | 0.95 | 0.969 | 125.7 | 10.54 | 2.87 | 0.359 | 10.54 | 2.87 | 0.359 | | | | |
| 2.350 | 53.8 | 16.41 | 0.18 | 460.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 276.0 | 10.86 | -1.87 | 0.338 | 10.86 | -1.87 | 0.338 | | | | |
| 2.400 | 54.6 | 16.13 | 0.18 | 338.2 | 0.35 | -2.67 | 0.978 | 0.35 | -2.67 | 0.978 | 202.9 | 10.98 | 0.30 | 0.319 | 10.98 | 0.30 | 0.319 | | | | |
| 2.450 | 55.4 | 15.84 | 0.18 | 364.7 | 0.00 | -3.48 | 1.000 | 0.00 | -3.48 | 1.000 | 218.8 | 11.02 | 0.38 | 0.304 | 11.02 | 0.38 | 0.304 | | | | |
| 2.500 | 56.2 | 15.56 | 0.18 | 176.2 | 0.35 | 2.06 | 0.977 | 0.35 | 2.06 | 0.977 | 105.7 | 10.52 | 3.5[illegible] | 0.324 | 10.52 | 3.56 | 0.324 | | | | |
| 2.550 | 57.0 | 15.27 | 0.18 | 204.3 | 0.08 | 1.06 | 0.995 | 0.08 | 1.06 | 0.995 | 125.6 | 10.38 | 3.00 | 0.320 | 10.38 | 3.00 | 0.320 | | | | |
| 2.600 | 57.8 | 14.98 | 0.18 | 231.4 | 0.01 | 0.43 | 0.999 | 0.01 | 0.43 | 0.999 | 138.8 | 9.81 | 2.54 | 0.345 | 9.81 | 2.54 | 0.345 | | | | |
| 2.650 | 58.5 | 14.69 | 0.18 | 270.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 163.8 | 9.92 | 1.88 | 0.325 | 9.92 | 1.88 | 0.325 | | | | |
| 2.700 | 59.2 | 14.40 | 0.18 | 302.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 181.3 | 9.22 | 1.27 | 0.350 | 9.22 | 1.27 | 0.350 | | | | |
| 2.750 | 59.9 | 14.11 | 0.18 | 383.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 230.1 | 9.46 | -0.03 | 0.330 | 9.46 | -0.03 | 0.330 | | | | |
| 2.800 | 60.6 | 13.82 | 0.18 | 441.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 264.7 | 9.46 | -0.99 | 0.316 | 9.46 | -0.99 | 0.316 | | | | |
| 2.850 | 61.3 | 13.53 | 0.18 | 518.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 311.3 | 9.56 | -2.26 | 0.293 | 9.56 | -2.26 | 0.293 | | | | |
| 2.900 | 62.0 | 13.24 | 0.18 | 585.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 351.3 | 10 | -3.18 | 0.219 | 10.34 | -3.18 | 0.219 | | | | |
| 2.950 | 62.6 | 12.95 | 0.18 | 596.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 358.0 | 10 | -3.29 | 0.174 | 10.70 | -3.29 | 0.174 | | | | |
| 3.000 | 63.3 | 12.66 | 0.18 | 403.7 | 0.06 | -4.74 | 0.995 | 0.06 | -4.74 | 0.996 | 242.2 | 11.17 | -0.19 | 0.117 | 11.17 | -2.19 | 0.117 | | | | |

[DX 708, P 44]

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3000. | 5.33 | 7.87 | 13.00 | 58.65 | .030 | .020 | .030 | 0.51 | 0.39 | 250.0 | 150.0 | 0.92 | 700. | .344 | 20.0 | | | | | |
| | 0.000 | 0.0 | 22.00 | 0.00 | 0.0 | 22.00 | 0.0 | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | 0.0 | 22.00 | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | | |
| | 0.050 | 1.1 | 21.78 | 0.23 | 663.6 | 16.13 | -9.41 | 0.256 | 16.13 | -9.41 | 0.260 | 390.2 | 16.76 | -5.64 | 0.139 | 10.76 | -3.14 | 0.139 | | | |
| | 0.100 | 2.2 | 21.47 | 0.17 | 544.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 470.4 | 8.48 | -7.48 | 0.605 | 8.48 | -7.48 | 0.605 | | | |
| | 0.150 | 3.2 | 21.21 | 0.16 | 170.4 | 0.20 | 1.56 | 0.991 | 0.20 | 1.56 | 0.991 | 107.0 | 4.96 | 2.30 | 0.766 | 4.96 | 2.30 | 0.766 | | | |
| | 0.200 | 4.3 | 20.93 | 0.19 | 153.9 | 7.47 | 3.88 | 0.643 | 7.47 | 3.88 | 0.643 | 92.3 | 11.42 | 3.53 | 0.454 | 11.42 | 3.53 | 0.454 | | | |
| | 0.250 | 5.3 | 20.65 | 0.16 | 284.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 170.6 | 7.43 | 0.64 | 0.643 | 7.43 | 0.64 | 0.643 | | | |
| | 0.300 | 6.4 | 20.37 | 0.18 | 394.1 | 1.86 | -3.92 | 0.908 | 1.86 | -3.92 | 0.908 | 236.5 | 10.82 | -0.82 | 0.469 | 10.82 | -0.82 | 0.469 | | | |
| | 0.350 | 7.4 | 20.09 | 0.17 | 265.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 159.5 | 9.03 | 1.14 | 0.551 | 9.03 | 1.14 | 0.551 | | | |
| | 0.400 | 8.4 | 19.82 | 0.17 | 427.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 256.6 | 9.06 | -1.61 | 0.543 | 9.06 | -1.61 | 0.543 | | | |
| | 0.450 | 9.4 | 19.54 | 0.18 | 354.6 | 1.66 | -2.56 | 0.915 | 1.66 | -2.56 | 0.915 | 212.8 | 11.49 | 0.06 | 0.412 | 11.49 | 0.06 | 0.412 | | | |
| | 0.500 | 10.3 | 19.26 | 0.18 | 189.4 | 0.27 | 1.87 | 0.986 | 0.27 | 1.87 | 0.986 | 113.6 | 9.85 | 2.72 | 0.489 | 9.85 | 2.72 | 0.489 | | | |
| | 0.550 | 11.3 | 19.97 | 0.18 | 293.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 176.1 | 11.10 | 1.19 | 0.415 | 11.10 | 1.19 | 0.415 | | | |
| | 0.600 | 12.2 | 18.69 | 0.18 | 176.3 | 0.44 | 2.23 | 0.977 | 0.44 | 2.23 | 0.977 | 105.8 | 10.62 | 3.22 | 0.432 | 10.62 | 3.22 | 0.432 | | | |
| | 0.650 | 13.1 | 18.40 | 0.18 | 451.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 271.0 | 11.12 | -1.36 | 0.395 | 11.12 | -1.36 | 0.395 | | | |
| | 0.700 | 14.1 | 18.11 | 0.18 | 426.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 255.6 | 11.11 | -0.85 | 0.387 | 11.11 | -0.85 | 0.387 | | | |
| | 0.750 | 15.0 | 17.83 | 0.18 | 480.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 288.3 | 11.05 | -1.73 | 0.380 | 11.05 | -1.73 | 0.380 | | | |
| | 0.800 | 15.8 | 17.54 | 0.18 | 495.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 297.3 | 11.01 | -1.96 | 0.372 | 11.01 | -1.96 | 0.372 | | | |
| | 0.850 | 16.7 | 17.26 | 0.18 | 483.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 290.3 | 11.07 | -1.72 | 0.359 | 11.07 | -1.72 | 0.359 | | | |
| | 0.900 | 17.6 | 16.98 | 0.18 | 521.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 313.0 | 10.99 | -2.39 | 0.353 | 10.99 | -2.39 | 0.353 | | | |
| | 0.950 | 18.4 | 16.70 | 0.17 | 463.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 278.0 | 11.08 | -1.36 | 0.336 | 11.08 | -1.36 | 0.336 | | | |
| | 1.000 | 19.2 | 16.42 | 0.17 | 505.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 303.3 | 11.01 | -2.09 | 0.330 | 11.01 | -2.09 | 0.330 | | | |
| | 1.050 | 20.1 | 16.14 | 0.17 | 485.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 291.1 | 11.05 | -1.72 | 0.316 | 11.05 | -1.72 | 0.316 | | | |
| | 1.100 | 20.9 | 15.86 | 0.17 | 516.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 309.8 | 10.97 | -2.26 | 0.308 | 10.97 | -2.26 | 0.308 | | | |
| | 1.150 | 21.6 | 15.58 | 0.18 | 495.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 297.1 | 11.05 | -1.86 | 0.291 | 11.05 | -1.86 | 0.291 | | | |
| | 1.200 | 22.4 | 15.30 | 0.18 | 503.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 302.1 | 11.06 | -1.97 | 0.277 | 11.06 | -1.97 | 0.277 | | | |
| | 1.250 | 23.2 | 15.02 | 0.18 | 492.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 295.2 | 11.10 | -1.72 | 0.261 | 11.10 | -1.72 | 0.261 | | | |
| | 1.300 | 23.9 | 14.73 | 0.18 | 487.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 289.6 | 11.16 | -1.49 | 0.243 | 11.16 | -1.49 | 0.243 | | | |
| | 1.350 | 24.6 | 14.45 | 0.18 | 484.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 290.9 | 11.20 | -1.48 | 0.225 | 11.20 | -1.48 | 0.225 | | | |
| | 1.400 | 25.4 | 14.16 | 0.18 | 410.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 246.4 | 11.30 | -0.13 | 0.201 | 11.30 | -0.13 | 0.201 | | | |
| | 1.450 | 26.1 | 13.86 | 0.19 | 359.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 215.4 | 11.38 | 0.83 | 0.179 | 11.38 | 0.83 | 0.179 | | | |
| | 1.500 | 26.7 | 13.57 | 0.18 | 209.9 | 0.09 | 1.14 | 0.993 | 0.09 | 1.14 | 0.993 | 125.9 | 10.65 | 3.29 | 0.215 | 10.65 | 3.29 | 0.215 | | | |
| | 1.550 | 27.4 | 13.27 | 0.10 | 249.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 149.6 | 10.51 | 2.63 | 0.208 | 10.51 | 2.63 | 0.208 | | | |
| | 1.600 | 28.1 | 12.97 | 0.18 | 298.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 179.2 | 9.87 | 1.69 | 0.239 | 9.87 | 1.69 | 0.239 | | | |
| | 1.650 | 28.7 | 12.68 | 0.18 | 336.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 202.1 | 10.07 | 1.14 | 0.206 | 10.07 | 1.14 | 0.206 | | | |
| | 1.700 | 29.3 | 12.38 | 0.19 | 322.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 193.4 | 10.27 | 1.49 | 0.170 | 10.27 | 1.49 | 0.170 | | | |
| | 1.750 | 29.9 | 12.09 | 0.18 | 263.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 158.1 | 10.63 | 2.20 | 0.120 | 10.63 | 2.20 | 0.120 | | | |
| | 1.800 | 30.5 | 11.81 | 0.17 | 447.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 268.3 | 10.82 | -2.00 | 0.083 | 10.82 | -2.00 | 0.083 | | | |
| | 1.850 | 31.1 | 11.53 | 0.18 | 454.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 272.6 | 10.16 | -1.03 | 0.118 | 10.16 | -1.03 | 0.118 | | | |
| | 1.900 | 31.7 | 11.25 | 0.17 | 301.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 180.6 | 10.15 | 1.07 | 0.098 | 10.15 | 1.07 | 0.098 | | | |
| | 1.950 | 32.3 | 10.99 | 0.15 | 209.8 | 0.04 | 0.75 | 0.996 | 0.04 | 0.75 | 0.996 | 125.9 | 10.35 | 0.86 | 0.056 | 10.35 | 0.86 | 0.056 | | | |
| | 2.000 | 32.8 | 10.75 | 0.14 | 304.2 | 0.41 | -1.85 | 0.962 | 0.41 | -1.85 | 0.962 | 182.5 | 10.26 | -1.60 | 0.045 | 10.26 | -1.60 | 0.045 | | | |
| | 2.050 | 33.3 | 10.51 | 0.16 | 392.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 235.5 | 9.62 | -0.94 | 0.064 | 9.62 | -0.94 | 0.064 | | | |
| | 2.100 | 33.8 | 10.27 | 0.15 | 278.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 167.0 | 9.56 | 0.31 | 0.059 | 9.56 | 0.31 | 0.059 | | | |
| | 2.150 | 34.4 | 10.03 | 0.18 | 543.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 326.3 | 8.66 | -2.18 | 0.136 | 8.66 | -2.18 | 0.136 | | | |
| | 2.200 | 34.8 | 9.76 | 0.14 | 218.4 | 0.83 | 0.77 | 0.915 | 0.83 | 0.77 | 0.915 | 131.0 | 9.38 | -0.45 | 0.039 | 9.38 | -0.45 | 0.039 | | | |
| | 2.250 | 35.3 | 9.49 | 0.18 | 295.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 177.0 | 8.18 | 2.11 | 0.139 | 8.18 | 2.11 | 0.139 | | | |
| | 2.300 | 35.8 | 9.25 | 0.17 | 465.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 279.6 | 8.30 | -1.53 | 0.102 | 8.30 | -1.53 | 0.102 | | | |
| | 2.350 | 36.2 | 8.98 | 0.13 | 180.4 | 0.70 | 1.96 | 0.922 | 0.70 | 1.96 | 0.922 | 108.2 | 8.65 | -0.06 | 0.036 | 8.65 | -0.06 | 0.036 | | | |
| | 2.400 | 36.7 | 8.71 | 0.18 | 358.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 214.8 | 7.10 | 0.90 | 0.185 | 7.10 | 0.90 | 0.185 | | | |
| | 2.450 | 37.1 | 8.46 | 0.17 | 360.4 | 0.54 | -3.99 | 0.936 | 0.54 | -3.99 | 0.936 | 214.2 | 7.79 | -1.24 | 0.060 | 7.79 | -1.14 | 0.060 | | | |
| | 2.500 | 37.5 | 8.17 | 0.15 | 181.5 | 0.27 | 1.91 | 0.967 | 0.27 | 1.91 | 0.967 | 108.9 | 7.75 | 0.93 | 0.091 | 7.75 | 0.93 | 0.091 | | | |
| | 2.550 | 37.9 | 7.92 | 0.10 | 534.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 320.9 | 6.45 | -2.19 | 0.185 | 6.45 | -2.19 | 0.185 | | | |
| | 2.600 | 38.3 | 7.65 | 0.16 | 227.2 | 1.64 | 1.50 | 0.785 | 1.64 | 1.50 | 0.785 | 136.3 | 7.34 | -0.55 | 0.041 | 7.34 | -0.55 | 0.041 | | | |
| | 2.650 | 38.7 | 7.37 | 0.18 | 287.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 172.6 | 6.02 | 2.06 | 0.162 | 6.02 | 2.06 | 0.162 | | | |
| | 2.700 | 39.1 | 7.11 | 0.19 | 420.1 | 1.70 | -3.90 | 0.760 | 1.70 | -3.90 | 0.760 | 252.0 | 6.46 | -1.18 | 0.092 | 6.46 | -1.18 | 0.092 | | | |
| | 2.750 | 39.4 | 6.82 | 0.14 | 171.7 | 0.41 | 2.38 | 0.939 | 0.41 | 2.38 | 0.939 | 103.0 | 6.51 | 0.69 | 0.045 | 6.51 | 0.69 | 0.045 | | | |
| | 2.800 | 39.7 | 6.56 | 0.18 | 554.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 332.8 | 5.20 | -2.59 | 0.207 | 5.20 | -2.59 | 0.207 | | | |
| | 2.850 | 40.1 | 6.29 | 0.14 | 175.5 | 1.84 | 3.24 | 0.705 | 1.85 | 3.24 | 0.706 | 105.3 | 6.09 | -0.34 | 0.031 | 6.09 | -0.34 | 0.031 | | | |
| | 2.900 | 40.4 | 6.03 | 0.18 | 377.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 226.4 | .07 | 0.13 | 0.321 | 4.07 | 0.13 | 0.321 | | | |
| | 2.950 | 40.7 | 5.75 | 0.17 | 454.4 | 3.36 | 2.10 | 0.426 | 3.10 | 2.10 | 0.426 | 152.6 | .48 | -0.63 | 0.047 | 5.48 | -0.63 | 0.047 | | | |
| | 3.000 | 41.0 | 5.48 | 0.18 | 279.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 167.9 | 3.89 | 1.91 | 0.286 | 3.89 | 1.91 | 0.286 | | | |

15 mph
.15 mu

DEFENDANT'S EXHIBITS OFFERED IN EVIDENCE AT TRIAL AND REJECTED

DANT'S EXHIBIT 13 FOR IDENTIFICATION (PAGES 1-4)

[DX 708, p 44]

E-1297

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED

WILMINGTON 98, DELAWARE

ENGINEERING DEPARTMENT

CC: C. R. Bigelow
R. C. 13

EXHIBIT 13.

RECEIVED
MR TIMES
FACTORY SALES

April 9, 1964

E. T. DARDEN
PLASTICS DEPARTMENT
WILMINGTON

ENGINEERING APPRAISAL OF "PERMA" ANTI-SKID DEVICE

As you requested on April 2, 1964, we have made a cursory review of the adequacy, utility, and reliability of the subject device. Since we have not had the opportunity to test a unit in actual use on a car, or under controlled conditions in a laboratory, we can only furnish an engineering opinion. It is our understanding that this investigation was deemed advisable as a result of a recent service failure in Detroit and because of the ramifications of a proposed advertising campaign.

The prevention of skidding, with attendant loss of steering control, is certainly a worthwhile objective. Skidding, however, can result from several circumstances, of which only one involves "panic" braking. The attached copy of an article from the March, 1964 edition of "Popular Science" Magazine describes more fully some of the recent research on causes of skids.

In addition to braking, skidding can also be caused by excessive speed, dangerous road conditions, and excessive acceleration. Since the "Perma" anti-skid system is only effective on skids associated with braking, it seems to us that it would be necessary to clearly inform the customer of this limitation to avoid lulling him into a false sense of security that could make him dangerously vulnerable to skids resulting from non-braking situations.

Based on published information and the experience of people of your own Department, there is no doubt about the effectiveness of the anti-skid device in controlling braking skids. It should be remembered, however, that the unit is not intended to shorten stopping distance, but only to provide steering control during hard braking.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

April 9, 1964
E. T. Darden

This limited evaluation is based on the technical literature furnished, a visual examination of the unit, and a telephone conversation with Frank Perrino, the inventor.

It appears that the design change made as a result of the Detroit incident will be effective in preventing this kind of failure. There are, however, a number of other types of possible failures that could occur.

Please keep in mind that we are not predicting these failures or attempting to define the probability, since this cannot be done without adequate test data.

Inherently, the basic design concept is not fail-safe since experience, as well as logic, shows that failure of the anti-skid device can result in the total loss of braking. Some of the types of possible failure that could result in loss of braking are:

1. Plugging of air filter No. 65 could result in the inability of the unit to cycle with partial or total loss of braking.
2. Failure of the solenoid spring No. 46 could prevent the unit from cycling with resultant loss of braking.
3. Displacement of the governor spring No. 47 into the clearance between the ends of the governor shaft and shaft No. 48 could result in loss of braking.
4. Welding of the contacts of pressure switch No. 38 could result in the inability of the unit to cycle with loss of braking.
5. Failure of the pressure switch spring No. 41 could similarly result in loss of braking.
6. Failure of the accumulator piston seals could result in loss of hydraulic fluid and braking failure.
7. Jamming of the pressure switch piston No. 39 while the switch is in the "closed" position could also result in failure to cycle with loss of braking.

In addition to these failures, there are four general component design categories involved in this device which would normally be the focus of a considerable amount of testing.

3
April 9, 1964
E. T. Darden

These are:

1. Gears and shafts - This marginally-lubricated drive train is particularly susceptible to failure under the conditions of operation. The governor shaft rotates at approximately 5000 rpm at 25 mph and at nearly 15,000 rpm at 75 mph (these figures were obtained from Perrino).

2. Switches - Switches operating in direct current circuits such as these can be a source of trouble.

3. Coil - The solenoid coil should be tested to determine reliability and longevity.

4. Plugged fluid passages - In addition to the air filter mentioned before, plugging could occur in the hydraulic system in the check valve and pressure switch which are introduced into the hydraulic brake line.

Our over-all impression is that the device represents an ingenious design, has been carefully developed, and is undoubtedly effective in controlling braking skids; but complexity and multiplicity of components make it vulnerable to sudden service failures with possible disastrous consequences. I would like to point out again that the probability of failure cannot be predicted without adequate tests.

Mr. Perrino has apparently made a considerable number of tests of the anti-skid unit, but certain important tests still need to be made. For example, cyclic functional sequencing tests to determine both system and component reliability have not been made. In a mechanical device like this where danger to life is involved, reliability should be established in the laboratory rather than in-service. In view of this, I would like to suggest that we make a more thorough investigation, including tests at the Engineering Test Center, before the proposed advertising is released.

Please advise if you would like us to prepare an estimate of this comprehensive engineering evaluation.

ENGINEERING SERVICE DIVISION
Packaging and Product Engineering Group

A. F. Barker

AFB:daf

A simplified antiskid device uses engine vacuum to control a variable accumulator for release of braking pressure in event of wheel lock-up. The redesigned unit, quickly installed on cars with or without power brakes, is a self-contained accessory that modulates brake-line pressure to a point just below the skid-producing pressure.

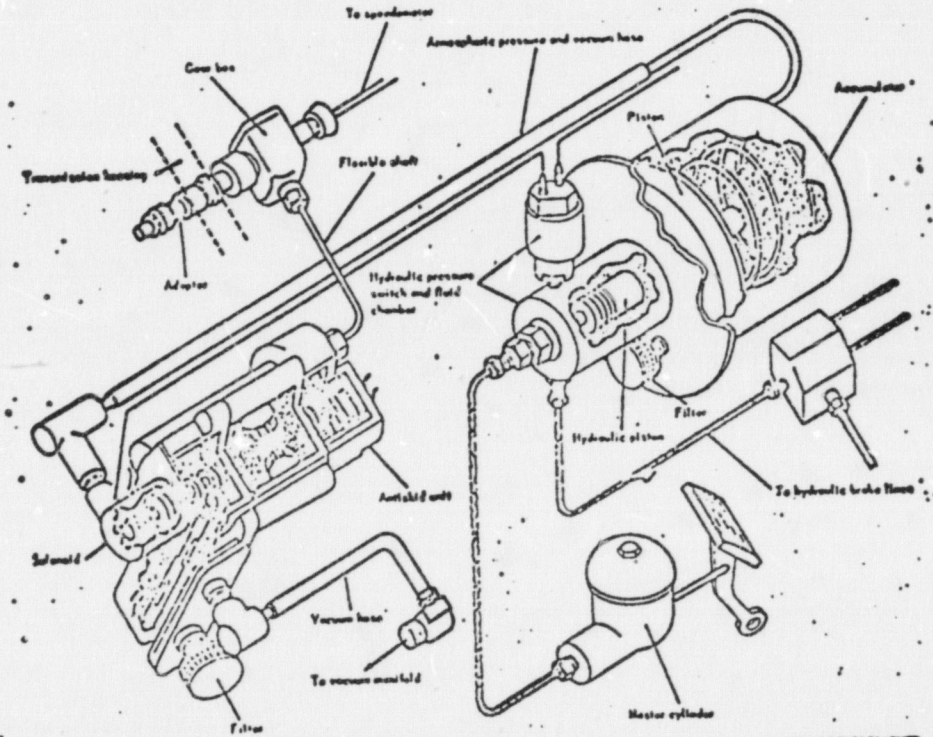
The original unit (DESIGN NEWS, April 11, 1960) provided combined automatic braking and skid control through the accelerator pedal. A later design was built around a power brake. Engine vacuum in both cases modulated brake pressure as regulated by a rotary valve. The latter effected release of skid pressure through a governor that responded to wheel lock-up. A safety valve allowed brake fluid to bypass the power brake and provide adequate pressure in event of engine failure or stall. In addition, damping was provided for the driver who wanted to avoid the sensitive feeling of the power brakes.

The redesign is independent of a specific braking arrangement and functions as an easily installed accessory. The antiskid unit is the same, except that now it simply regulates a separate variable accumulator, only in event of a skid condition. Engine vacuum releases the brake-line pressure to just below the skid level when a wheel lock-up condition occurs. Vacuum is fed to the release side of the accumulator through the rotation of the rotary valve in the antiskid unit. At the same time, closing of a valve in the hydraulic section of the accumulator prevents overriding of the antiskid system by the driver.

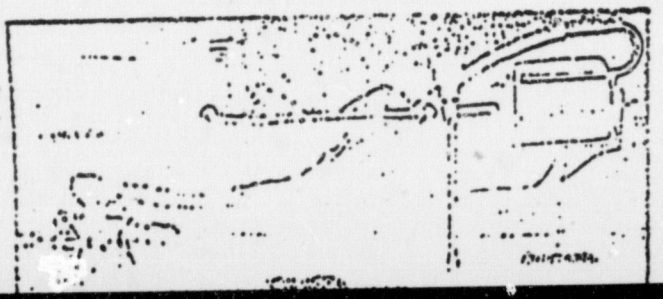
There is no change in the "feel" of the brake pedal after the unit is installed. Also, since the device does not rely on vacuum for braking power, there is no need for the safety valve and associated lines and fittings.

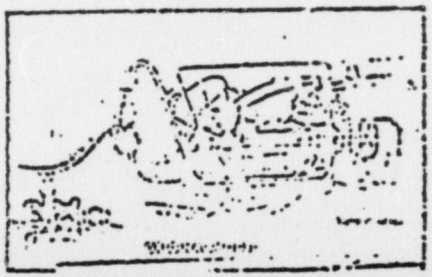
The redesigned antiskid control is a product of Perma Research and Development Co., North Attleboro, Mass.

[DX 13 for id, p 4]




**SELF-CONTAINED UNIT** *supplements existing braking system. Governor senses locked wheel condition and modulates rotary valve. Solenoid assures that antiskid system will be open two ends during skid*





**UNIT WITH POWER BRAKE** *required replacement of existing braking system and complicated installa-*

DEFENDANT'S EXHIBIT 335 FOR IDENTIFICATION

Messrs. E. Doriss
C. W. Drecker
R. H. Zinna

cc: Mr. A. Rozel

E. C. Person

February 15, 1966

VISIT TO KELSEY-HAYES

The purpose of this memorandum is to pass along some of the highlights of the discussion Mr. Rozel and I had with Kelsey-Hayes during our visit of February 3.

The summary and conclusion of their test of the Perma Anti-Skid unit is included as Exhibit III in the material we presented to Mr. Kircher, of which each of you should have a copy.

Their highlights are as follows:

1. Our conversation confirmed the design criteria we have been using for minimum pressures - 1,000 P.S.I. Their engineer indicated that the minimum should be increased at least 200 P.S.I. for disc brakes. (From his experience, Mr. Rozel believes the minimum would have to be increased further.)

2. Kelsey-Hayes engineers indicated they felt vacuum was not a good source of power for an anti-skid device because it limits the cycles per second. From experimental work that they have done, they indicated the following practical cycle rates:

   Vacuum - about 5 cycles per second

   Compressed Air - about 25 cycles per second

   Hydraulic Pressure - about 350-400 cycles per second

   While they had not instrumented the car, they estimated the anti-skid unit was cycling somewhere between 3-5 cycles per second, which is too slow; a frequency of 10 cycles per second would be more successful.

3. The optimum stopping rate is 27' per second, per second. Some cars equipped with Kelsey-Hayes brakes are already approaching this optimum.

4. Kelsey-Hayes believes the cost target for an anti-skid unit would be $30-$40 at the retail level, which means $9-$10 factory cost.

Original signed by
E. C. Person

ECP:ER

#335

After viewing all available copies of the preceding page, counsel for Appellant believes that said page reads as follows:

Messrs. B. Boriss
C.W. Brecker
R.H. Zimann

cc: Mr. A. Romel

B.C. Person

February 15, 1966

VISIT TO KELSEY-HAYES

The purpose of this memorandum is to pass along some of the highlights of the discussion Mr. Romel and I had with Kelsey-Hayes during our visit of February 3.

The summary and conclusion of their test of the Perma Anti-Skid unit is included as Exhibit III in the material we presented to Mr. Kircher, of which each of you should have a copy.

Their highlights are as follows:

1. Our conversation confirmed the design criteria we have been using for minimum pressures - 1,000 P.S.I. Their engineer indicated that the minimum should be increased at least 200 P.S.I. for disc brakes. (From his experience, Mr. Romel believes the minimum would have to be increased further.)

2. Kelsey-Hayes engineers indicated they felt vacuum was not a good source of power for an anti-skid device because it limits the cycles per second. From experimental work that they have done, they indicated the following practical cycle rates:

   Vacuum - about 5 cycles per second

   Compressed Air - about 25 cycles per second

   Hydraulic Pressure - about 300-400 cycles per second

   While they had not instrumented the car, they estimated the anti-skid unit was cycling somewhere between 3-5 cycles per second, which is too slow; a frequency of 10 cycles per second would be more successful.

3. The optimum stopping rate is 27' per second, per second. Some cars equipped with Kelsey-Hayes brakes are already approaching this optimum.

4. Kelsey-Hayes believes the cost target for an anti-skid unit would be $30-$40 at the retail level, which means $0-$10 factory cost.

Original signed by

B.C.Person

KELSEY-HAYES COMPANY

INTER DEPARTMENT CORRESPONDENCE

[DX 335 for id, p 21]

February 3, 1966

To: H. Hayes

From: J. Avery

Subject: Evaluation of the Power Anti-Skid System

Object: The object of this evaluation was to determine whether the Power-Anti-Skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Power-Anti-Skid System was loaned to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the brake manifold connection was through a 3/8" diameter bore hose, the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance & directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult to maintain and on many of the 60 m.p.h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

The major objection to the system is that the rear wheels are required to lock completely before the brake pressure is reduced which is the primary cause for the instability and jerkiness.

The test have not indicated that the System or any of its components offer any promise for development in a Kelsey-Hayes System. It must be pointed out here that no instrumentation was used on the system thus the possibility of any system modifications to improve performance cannot be determined accurately.

Test Procedure:

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration, stopping distance and vehicle stability.

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.

335

(transcribed on page E-1303A)

After viewing all available copies of the preceding page, councel for Appellant believes that said page reads as follows:

February 3, 1966

To: M. Meyer

From: (P?) (Every?)

Subject: Evaluation of the Perma Anti-Skid System

Object: The object of this evaluation was to determine whether the Perma Anti-Skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Perma Anti-Skid System was (loaned?) to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the intake manifold connection was through a (?/?)" diameter ?..., the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance and directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult to maintain and on many of the 60 m.p.h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

The major objection to the system is that the rear wheels are required to lock completely before the brake pressure is reduced which is the primary cause for the instability and jerkiness.

The test have not indicated that the System or any of its components offer any promise for development in a Kelsey-Hayes System. It must be pointed out (?) that no instrumentation was used on the system thus the possibility of any system modifications to improve performance cannot be determined accurately.

Test Procedure:

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration stopping distance and vehicle stability.

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum tank and check valve between the manifold and system.

Test Results:

All the 20 m.p.h. stops were stable with little or no steering correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

The average stopping distance on wet pavement was the same for four wheel or rear only pumping, and without the system.

The majority of the 60 m.p.h. stops required considerable steering correction to keep the car on the road and on several occasions the brake pedal had to be released. The car was generally more easily controlled without the system operating. The few straight stops were achieved when the front wheels locked during the first part of the stop. The stopping distances with the system operating were generally equal to or greater than without the system on wet pavements.

Several occasions one rear wheel locked for 30 feet or more before the other, under these conditions the system cannot pump. Generally the car slide a considerable distance before the pumping action could be detected except for the test made in configuration 6, when the system started pumping immediately after the rear wheel locked, however, straight stops could only be achieved by limiting the applied pressure.

The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Lincoln.

Conclusions:

On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

P. Dery

P.Dery/sh



(transcribed on page E-1304A)

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum (tank?) and check valve between the manifold and system.

Test Results:

All the (30?) m.p.h. stops were (stable?) with little or no stearing correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

The average stopping distance on wet pavement was the same for four wheel or rear only pumping, and without the system.

The majority of the 60 m.p.h. stops required considerable steering correction to keep the car on the road and on several occasions the brake pedal had to be released. The car was generally more easily controlled without the system operating. The few straight stops were achieved when the front wheels locked during the first part of the stop. The stopping distances with the system operating were generally equal to or greater than without the system on wet pavement.

Several occasions one rear wheel locked for 30 feet or more before the other, under these conditions the system cannot pump. Generally the car skids a considerable distance before the pumping action could be detected except for the test made in configuration (6?), when the system started pumping immediately after the rear wheel locked, however, straight stops could only be achieved by limiting the applied pressure.

The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Lincoln.

Conclusions:

On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceeded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

(P. Every?)

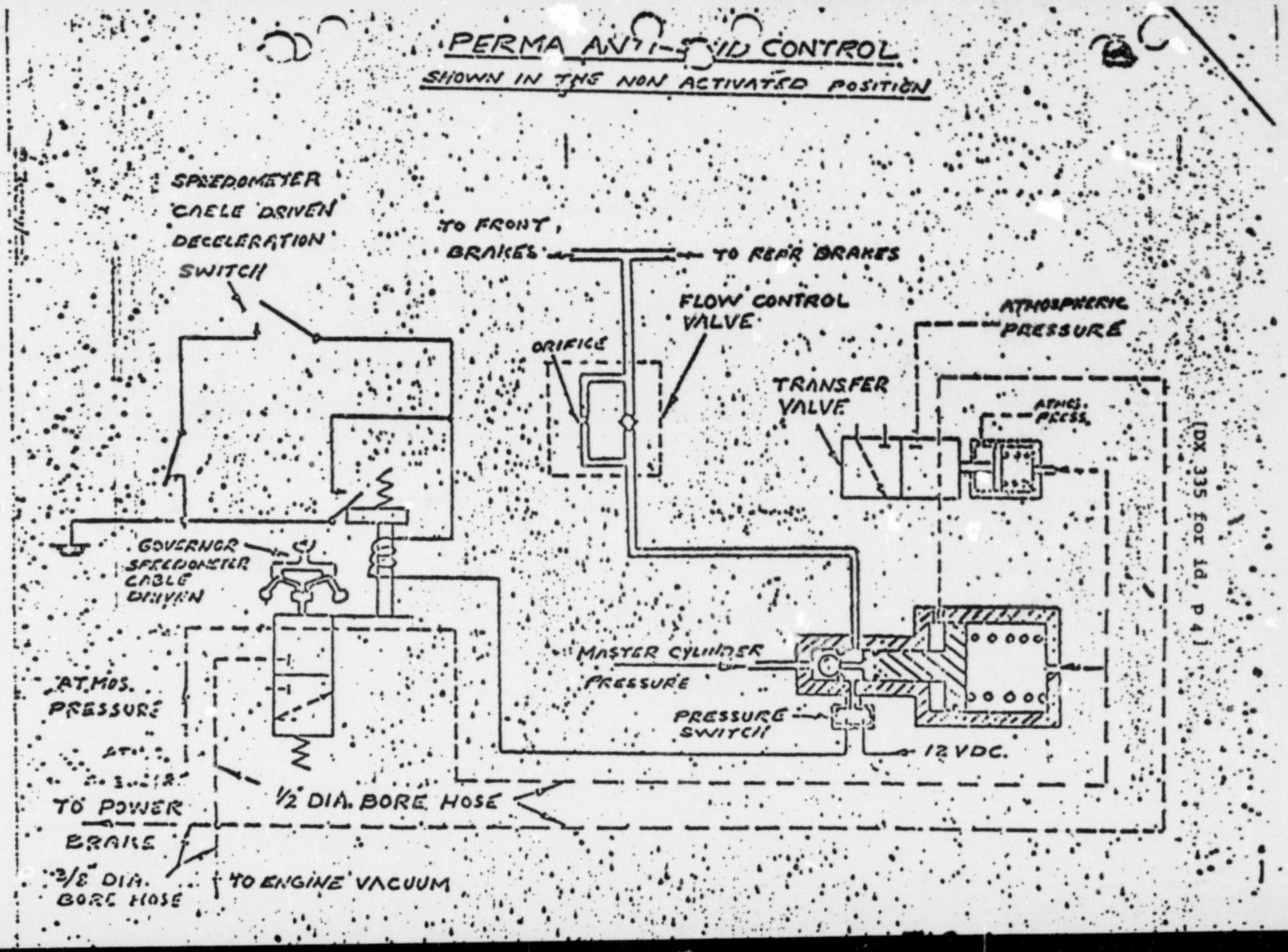
(P. Every/mek?)



[DX 335 for id, p 4]

# PERMA ANTI-SKID CONTROL

SHOWN IN THE NON ACTIVATED POSITION




E-1305

DX 335 for Id. P4

February 3, 1966

Kelsey-Hayes Company
Inter-Department Correspondence

D-335
Transcription

To: M. MEYER

From: P. EVERY

Subject: Evaluation of the Perma Anti-Skid System

Object: The object of this evaluation was to determine whether the Perma-Anti-skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Perma Anti-Skid System was loaned to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the intake manifold connection was through a 3/8" diameter bore hose, the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance and directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult

to maintain and on many of the 60 m.p.h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

The major objection to the system is that the rear wheels are required to lock completely before the brake pressure is reduced which is the primary cause for the instability and jerkiness.

The tests have not indicated that the System or any of its components offer any premise for development in a Kelsey-Hayes System. It must be pointed out here that no instrumentation was used on the system thus the possibility of any system modifications to improve performance cannot be determined accurately.

Test Procedure: The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration, stopping distance and vehicle stability.

[DX 335 for id, p 7]

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum tank and check valve between the manifold and system.

**Test Results:** All the 30 m.p.h. stops were stable with little or no steering correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

The average stopping distance on wet pavement was the same for four wheel or rear only pumping, and without the system.

[DX 335 for id, p 8]

The majority of the 60 m.p.h. stops required considerable steering correction to keep the car on the road and on several occasions the brake pedal had to be released. The car was generally more easily controlled without the system operating. The few straight stops were achieved when the front wheels locked during the first part of the stop. The stopping distances with the system operating were generally equal to or greater than without the system on wet pavement.

Several occasions one rear wheel locked for 30 feet or more before the other, under these conditions the system can not pump. Generally the car skids a considerable distance before the pumping action could be detected except for the test made in configuration 6, when the system started pumping immediately after the rear wheel locked, however, straight stops could only be achieved by limiting the applied pressure.

The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Lincoln.

**Conclusions:** On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

P. Every

DEFENDANT'S EXHIBIT 337 FOR IDENTIFICATION

ENGINEERING REPORT

Confidential

P+S 7-11 Rec'd 3-18-71 8:

DATE: 3-23-66

E.O.A. NO. 76264

W.P.C. NO. 6

PROJECT NO.

☒ INFORMATION ONLY ☐ REPLY REQUIRED

TO: Mr. A. E. Samson

cc: Mr. J. Brown
Mr. O. D. Dillman
Mr. D. F. Fiscus
Mr. R. Miller
Mr. D. P. Renner
Mr. A. C. Sampietro
Library (2)

SUBJECT: Singer Anti-Skid Control Unit

Object: To determine the stopping distance and directional stability under various road conditions of a vehicle equipped with the Singer Anti-Skid Control Unit.

Conclusions:

Test results indicate that the Singer Anti-Skid Control Unit, installed according to the manufacturer's instructions, is ineffective in improving the stopping distance and directional stability of a vehicle on various road surfaces. It was found that on slippery surfaces (coefficient of friction between tire and road equal to or less than 0.5), the device proved inoperative. The inadequacies can be attributed to use of a restrictor valve in the hydraulic system, failure to compare vehicle deceleration with driveline deceleration, and system inertia inherent in vacuum lines and pistons.

Recommendations:

After testing the Singer Anti-Skid Control Unit under various conditions, it must be recommended that further testing be discontinued as the device offers no potential in its present state.

Discussion:

Description of Unit

The Singer Anti-Skid Unit consists of two major components; one for sensing driveline rotation (Sensing Unit), the other for modulating the brake line pressure when the rear wheels lock (Perma-Vac Unit). The Sensing Unit is connected to the speedometer drive gear by means of a flexible cable. When the brakes are applied to the point of rear wheel lock-up, driveline rotation ceases and this cessation causes the governor in the sensing unit to actuate a valve. This valve vents the rear section of the Perma-Vac Unit to vacuum, a condition which retracts a piston in the hydraulic system and reduces the brake line pressure to both the front and rear brakes.

As this pressure is reduced, the rear wheels begin to turn again, causing the governor to reposition the valve, venting the rear section of the Perma-Vac Unit to the atmosphere and the front section to intake manifold vacuum. This condition forces the piston into the hydraulic system restoring the brake line pressure to its original value. This sequence of operations continues throughout the skid until the vehicle speed is reduced to approximately 8 mph, whereupon, full brake line pressure is restored and maintained.

APPROVED: C. D. Ibbotson D.P.E. 337 SIGNED: W. J. Kilkahon
C. D. Ibbotson

Description of Unit (Con't)

In addition to the above two components, there is a restrictor valve in the brake lines between the Perma-Vac Unit and the wheel cylinders. This valve limits the minimum brake line pressure to approximately 175 psi during the cycling, a condition designed to reduce stopping distance by maintaining contact between the brake shoes and drums.

Vehicle, Instrumentation, and Unit Installation

The vehicle used for the evaluation was a 1966 Ford Custom 500 4-door sedan equipped with the following:

- 390-2V CID engine
- 3-speed automatic transmission
- Power drum brakes
- Power steering
- 7.75 x 15, 4-ply rated tires inflated to 24 psi.

In order to evaluate the anti-skid system, the following instrumentation was installed on the vehicle:

- Wheel rotation indicators (4) - to check for lockup.
- Line pressure indicators (2) - to record front and rear line pressure.
- Accelerometers (2) - to record longitudinal and lateral acceleration.
- Fifth wheel - to record velocity and stopping distance.
- Oscillograph recorder.

With this instrumentation, a driver, and an observer, the vehicle weight was recorded as follows:

Front - 2436 lbs.

Rear - 2116 lbs.

TOTAL - 4552 lbs.

Vehicle, Instrumentation, and Unit Installation (Con't)

The Singer Unit was installed in the test vehicle in such a way that it could be turned off completely, allowing for evaluation of the standard brake system, or be isolated from the front brakes, allowing modulation of the rear brakes only and leaving the front brakes connected directly to the master cylinder. Provision was also made for removing the restrictor valve in order to judge its effect on stopping distance.

Test Procedure

All stops were hands off the wheel panic stops with the car in neutral. Some driving was done between stops in order to maintain cool brakes and thus avoid fade. For each road condition, the car was tested with the anti-skid unit turned off, with it turned on and pulsing four brakes, and with it on but pulsing the two rear brakes only, the front brakes being connected directly to the master cylinder. Stops were run both with and without the hydraulic restrictor valve in the system. The following is a list of road conditions and speeds from which stops were made.

I. With Hydraulic Restrictor Valve

A. Stops from 10, 20 and 30 mph, with four wheels on soaped paint stripe:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

B. Stops from 10 and 20 mph, with two right wheels on soaped paint stripe and two left wheels on dry asphalt:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

C. Stops from 10, 20 and 30 mph, with four wheels on wet paint stripe:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

I. With Hydraulic Restrictor Valve (Con't)

D. Stops from 10, 20 and 40 mph, with four wheels on wet asphalt:

1. With anti-skid off

2. With anti-skid pulsing four brakes

3. With anti-skid pulsing rear brakes and constant pressure to front brakes

E. Stops from 10, 20 and 40 mph, with four wheels on dry asphalt:

1. With anti-skid off

2. With anti-skid pulsing four brakes

3. With anti-skid pulsing rear brakes and constant pressure to front brakes

II. With Hydraulic Restrictor Valve Removed

A. Stops from 20 and 30 mph, with four wheels on scraped paint strips:

1. With anti-skid off

2. With anti-skid pulsing four brakes

3. With anti-skid pulsing rear brakes and constant pressure to front brakes.

B. Stops from 20 and 30 mph, with four wheels on wet paint strips:

1. With anti-skid off

2. With anti-skid pulsing four brakes

3. With anti-skid pulsing rear brakes and constant pressure to front brakes

C. Stops from 10, 20 and 40 mph, with four wheels on wet asphalt:

1. With anti-skid off

2. With anti-skid pulsing four brakes

3. With anti-skid pulsing rear brakes and constant pressure to front brakes

Summary of Test Results

The attached tables summarize the average stopping distances recorded during the tests. No substantial differences in stopping distance for similar road conditions are indicated.

Visual observation of stability indicated that with the Singer Anti-Skid Unit modulating all four brakes, no increase in stability over the standard vehicle was achieved, and in some cases stability was lessened. Test recordings indicated that four brake modulation induced lateral accelerations in the vehicle and thus decreased its stability. With only the two rear brakes being modulated, a condition not investigated by the manufacturer, some increase in stability over the standard vehicle for some road conditions was recorded. In addition, this was the system favored by the test driver. He commented that the car seemed more stable when only the rear brakes were being modulated.

The restrictor valve that the Singer Company installed in the Anti-Skid Unit detracted from its performance on slippery surfaces. When the pressure was reduced, it never dropped low enough to unlock the rear wheels on even wet paint strips. Consequently, the Unit cycled once and then reapplied full line pressure for the remainder of the stop. Even without the restrictor valve, the Unit did not cycle effectively on soaped paint strips, a road condition which simulated wet ice.

With the Unit modulating all four brakes and without the restrictor valve some improvement in stopping distance over the standard vehicle was recorded on wet paint strips. However, an increase in stopping distance over the standard vehicle was recorded for wet asphalt.

The following is a resume of stopping distances and stability for various conditions of system and road.

I. With Restrictor Valve

Average Stopping Distance

| ROAD CONDITION AND NOMINAL SPEED | A/S OFF | A/S ON | A/S ON REAR ONLY |
|---|---|---|---|
| A. 4-wheels on soaped paint | | | |
| 10 | 17.5 | 18.2* | 18.7* |
| 20 | 81.2 | 86.3* | 83.2* |
| 30 | 206.3 | 221.0* | 202.5* |
| B. 2-wheels on soaped paint 2-wheels on dry asphalt | | | |
| 10 | 7.5 | 8.8* | 8.6* |
| 20 | 31.7 | 30.4 | 35.6 |
| C. 4-wheels on wet paint | | | |
| 10 | 7.9 | 8.5 | 7.6 |
| 20 | 44.9 | 40.2 | 46.1 |
| 30 | 108.7 | 115.5 | 101.8 |
| D. 4-wheels on wet asphalt | | | |
| 10 | 4.2 | 4.7 | 4.7 |
| 20 | 14.8 | 15.5 | 16.0 |
| 40 | 74.7 | 68.9 | 72.2 |
| E. 4-wheels on dry asphalt | | | |
| 10 | 4.5 | 4.5 | 4.4 |
| 20 | 15.3 | 16.6 | 16.6 |
| 40 | 67.8 | 70.5 | 70.3 |

* Perma-Vac Unit only cycled once.

II. Without Restrictor Valve

Average Stopping Distance-Ft.

| ROAD CONDITION AND NOMINAL SPEED | A/S OFF | A/S ON | A/S ON REAR ONLY |
|---|---|---|---|
| A. 4-wheels on soaped paint | | | |
| 20 | 84.6 | 65.0‡ | 84.5* |
| 30 | 206.3 | 202.9 | 211.3 |
| B. 4-wheels on wet paint | | | |
| 20 | 38.8 | 39.9 | 37.6 |
| 30 | 102.8 | 101.1 | 120.7 |
| C. 4-wheels on wet asphalt | | | |
| 10 | 3.9 | 4.8 | 3.7 |
| 20 | 14.6 | 21.0 | 15.2 |
| 30 | ---- | 78.5 | 70.2 |

‡ Indications are that the coefficient of friction between road and tire was higher than normal.

* Perma-Vac Unit only cycled once.

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR |
|---|---|---|---|---|
| I. With Restrictor Valve | | | | |
| A. 4-wheels on soaped paint | | | | |
| 1. Anti-Skid off | 9.7 | 18.6 | | |
| | 9.4 | 16.4 | | 2" RT |
| | 20.7 | 86.3 | 6" RT | |
| | 20.2 | 76.0 | 15° YAW | |
| | 29.9 | 189.9 | 15° YAW | |
| | 30.7 | 200.8 | 15° YAW | |
| | | | 45° YAW | |
| 2. Anti-Skid Pulsing four brakes | 9.6 | 19.0 | Stable | |
| | 9.3 | 17.3 | 6" RT | |
| | 19.8 | 88.2 | 8" LFT | |
| | 19.6 | 80.2 | 5° YAW | |
| | 30.5 | 229.0 | 60° YAW | |
| | 30.5 | 213.0 | 60° YAW | |
| 3. Anti-Skid Pulsing rear brakes only | 9.7 | 20.3 | Stable | |
| | 9.6 | 17.1 | | 6" RT |
| | 20.2 | 78.1 | 18" RT | |
| | 20.4 | 88.2 | 6" Sway & Recover | |
| | 30.3 | 199.5 | Slight Sway | |
| | 30.5 | 205.5 | Sway & Recover | |

| CONDITION | SPEED MPH. | STOPPING DISTANCE —FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CY |
|---|---|---|---|---|---|
| I B. 2-wheels on soaped paint 2-wheels on dry asphalt | | | | | |
| 1. Anti-Skid off | 9.1 | 7.4 | | 1' RT | |
| | 9.3 | 7.5 | | 1' RT | |
| | 19.0 | 32.4 | 1' LFT | 4' RT | |
| | 19.3 | 30.9 | 1' LFT | 4' RT | |
| 2. Anti-Skid Pulsing four brakes | 9.2 | 7.1 | | 1' RT | 1 |
| | 9.7 | 8.6 | | 1½' RT | 1 |
| | 19.7 | 29.9 | 1' LF | 4' RT | 4 |
| | 20.1 | 30.1 | 1' LFT | 4' RT | 5 |
| 3. Anti-Skid Pulsing rear brakes only | 10.4 | 9.3 | 1' LFT | 1' RT | 1 |
| | 9.7 | 8.0 | 1½' RT | | 1 |
| | 20.0 | 33.9 | 45° YAW | | 5 |
| | 19.0 | 33.7 | 30° YAW | | 5 |

| CONDITION | SPEED MPH. | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CY |
|---|---|---|---|---|---|
| I C. 4-wheels on wet paint | | | | | |
| 1. Anti-Skid off | 10.0 | 7.8 | Stable | | |
| | 10.0 | 7.9 | Stable | | |
| | 20.2 | 41.3 | 8" RT | | |
| | 20.6 | 48.4 | 1' LFT | 6" RT | |
| | 30.2 | 112.6 | 1' RT | 6" LFT | |
| | 30.7 | 104.8 | 3' RT | 1' LFT | |
| 2. Anti-Skid Pulsing four brakes | 9.7 | 8.6 | Stable | | 2 |
| | 10.0 | 8.5 | Stable | | 1 |
| | 20.2 | 47.5 | 8" RT | | 1 |
| | 20.6 | 32.9 | 1' LFT | | 1 |
| | 30.5 | 130.0 | 3' RT | 1' RT | 1 |
| | 30.9 | 100.9 | 3' RT | 1' RT | 1 |
| 3. Anti-Skid Pulsing rear brakes only | 10.0 | 8.0 | Stable | | 3 |
| | 9.6 | 7.2 | Stable | | 1 |
| | 20.1 | 46.6 | 1' RT | | 1 |
| | 20.8 | 45.5 | 1' RT | | 1 |
| | 30.1 | 95.0 | Sway & Recovery | | 4 |
| | 30.9 | 108.6 | 1' LFT | | 1 |

| CONDITION | SPEED M.P.H. | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | CYC |
|---|---|---|---|---|---|
| I D. 4-wheels on wet asphalt | | | | | |
| 1. Anti-Skid | 9.4 | 4.7 | Stable | | |
| | 9.7 | 3.7 | Stable | | |
| | 20.1 | 13.7 | Stable | | |
| | 19.6 | 16.0 | Stable | | |
| | 40.3 | 77.9 | 4" RT | | |
| | 41.0 | 71.5 | 1' RT | | |
| 2. Anti-Skid Pulsing four brakes | 9.6 | 4.5 | Stable | | 0 |
| | 9.7 | 4.8 | Stable | | 0 |
| | 20.1 | 15.8 | Stable | | 3 |
| | 20.5 | 15.2 | Stable | | 3 |
| | 41.6 | 66.1 | | 1½' RT | 7 |
| | 41.1 | 71.1 | 6" LFT Drift | RT | 6 |
| 3. Anti-Skid Pulsing rear brakes only | 10.4 | 4.9 | Stable | | 0 |
| | 9.2 | 4.5 | Stable | | 0 |
| | 20.0 | 16.3 | 2" LFT, | | 3 |
| | 20.1 | 15.6 | Stable | | 3 |
| | 40.4 | 74.5 | Stable | | 6 |
| | 40.6 | 69.8 | | 3" RT | 6 |

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NOISE CY |
|---|---|---|---|---|---|
| I E. 4-wheels on dry asphalt | | | | | |
| 1. Anti-Skid off | 10.1 | 4.3 | Stable | | |
| | 10.4 | 4.7 | Stable | | |
| | 20.3 | 14.8 | | Drift RT | |
| | 20.5 | 15.7 | | Drift RT | |
| | 40.5 | 68.1 | Drift RT | 1' RT | |
| | 40.7 | 67.4 | | 4" RT | |
| 2. Anti-Skid Pulsing four brakes | 10.0 | 4.3 | Stable | | |
| | 9.7 | 4.7 | Stable | | |
| | 19.8 | 15.9 | Stable | | |
| | 19.6 | 17.3 | | 2" RT | |
| | 39.1 | 71.0 | Drift LFT | 6" RT | |
| | 39.3 | 70.0 | 1' RT | Drift RT | |
| 3. Anti-Skid Pulsing rear brakes only | 9.6 | 4.5 | Stable | | |
| | 9.7 | 4.2 | Stable | | |
| | 19.6 | 16.1 | Stable | | |
| | 19.4 | 17.0 | Stable | | |
| | 39.0 | 72.5 | | 1" RT | |
| | 39.5 | 72.0 | Stable | | |

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| II. Without Restrictor Valve | | | | | |
| A. 4-wheels on coated paint | | | | | |
| 1. Anti-Skid off | 20.2 | 81.5 | 2' LFT | 8" LFT | |
| | 20.2 | 87.7 | 2' LFT | 8" LFT | |
| | 31.0 | 186.5 | 8" RT | | |
| | 30.6 | 155.6 | | 8" RT | |
| 2. Anti-Skid Pulsing four brakes | 19.8 | 63.4 | 1½' RT | 6" LFT | 5 |
| | 20.5 | 66.5 | 1½' RT | 6" LFT | 7 |
| | 30.7 | 218.5 | 60° YAW | | 1 |
| | 30.6 | 187.3 | 70° YAW | | 2 |
| 3. Anti-Skid Pulsing rear brakes only | 20.2 | 91.4 | 15° YAW | | 1 |
| | 19.8 | 77.6 | Sway & Recovery | | 1 |
| | 30.4 | 221.5 | Yaw off Strip | | 2 |
| | 31.0 | 201.0 | Yaw off Strip | | 1 |

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCL |
|---|---|---|---|---|---|
| II B. 4-wheels on wet paint. | | | | | |
| 1. Anti-Skid off | 20.4 | 38.8 | 1' RT | 4" LFT | |
| | 29.9 | 106.1 | 30° YAW | | |
| | 30.5 | 99.5 | 30° YAW | | |
| 2. Anti-Skid Pulsing four brakes | 20.4 | 34.4 | Drift RT | | 6 |
| | 20.5 | 37.3 | 1' LFT | | 5 |
| | 30.9 | 97.8 | 45° YAW | | 7 |
| | 31.0 | 104.3 | 30° YAW | | 7 |
| 3. Anti-Skid Pulsing rear brakes only | 20.1 | 39.8 | 6" RT | | 7 |
| | 20.8 | 35.4 | 6" RT | | 7 |
| | 30.5 | 122.6 | 2' LFT | 3' RT | 10 |
| | 30.5 | 118.7 | 2' RT | 1' LFT | 9 |

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYC |
|---|---|---|---|---|---|
| II C. 4-wheels on wet asphalt | | | | | |
| 1. Anti-Skid off | 9.7 | 3.8 | Stable | | |
| | 9.5 | 3.9 | Stable | | |
| | 20.4 | 14.9 | Stable | | |
| | 20.4 | 14.6 | Stable | | |
| | 20.5 | 14.4 | Stable | | |
| 2. Anti-Skid Pulsing four brakes | 9.8 | 4.4 | Stable | | 0 |
| | 9.7 | 5.1 | Stable | | 0 |
| | 20.4 | 21.2 | Stable | | 3 |
| | 20.2 | 20.7 | Stable | | 3 |
| | 41.4 | 78.7 | 6" RT | | 6 |
| | 40.8 | 78.2 | 1' LFT | | 6 |
| 3. Anti-Skid Pulsing rear brakes only | 9.4 | 3.9 | Stable | | 0 |
| | 9.8 | 3.5 | Stable | | 0 |
| | 20.6 | 15.4 | Stable | | 3 |
| | 20.8 | 15.0 | | 6" RT | 4 |
| | 40.9 | 71.4 | Slight Sway | | 6 |
| | 41.5 | 69.0 | Slight Sway | | 6 |

DEFENDANT'S EXHIBIT 510 FOR IDENTIFICATION

MEMORANDUM

RECEIVED
OCT 15 1965
MFG. ENG. DEPT.
39

SINGER
CENTRAL RESEARCH LABORATORY
DENVILLE, NEW JERSEY

Copy for H. Sh
E. Pyne
and file.

TO: Mr. J. W. Momberg

FROM: Mr. J. A. Lundin

DATE: October 7, 1965 REFER TO: JAL:ck

SUBJECT: Meeting at Denville Research Laboratory on September 30, 1965.

Subject: Perma Anti-Skid Brake Control System from the Aspect of Functional Design and Reliability.

Present: Messrs. A. Romel and C. Papczun - Elizabeth Factory.
J.W. Momberg and J.A. Lundin - Denville.

Purpose of Meeting:

The meeting was arranged to bring the Central Research Laboratory personnel up to date on the experience acquired by the Elizabeth Factory personnel with the Perma Anti-Skid Brake Control System. The Denville personnel have been requested to assist in a technical evaluation of the Perma Anti-Skid Control from the aspect of functional design within the patent protection claimed and reliability not detractive of existing brake systems.

Discussion:

The discussion was guided by questions prepared in advance and is presented in the same form in this meeting report. The term components refers to units, such as the sensor and Perma-Vac assemblies, and to individual components, such as the rotary valve, governor, pressure switch and solenoid. The term adaptors refers to active units to be supplied in the Perma kits to accommodate vehicle differences.

FUNCTIONAL DESIGN:

1. Are the components functioning in accordance with the intended purpose of each component?

It was stated that the Perma system does not function in the mode of Perma's original claim to cycle near the locked-wheel pressure, but cycles between the pressure switch setting (low limit Perma control of brake fluid pressure) and levels just above locked-wheel pressure.

The transfer valve had to be added to the Perma-Vac unit to apply vacuum to the originally-inactive side of the diaphragm to modify a functional deficiency that set an unacceptable limit on the brake pressure during non-panic braking.

DPE
510

The Perma-Vac unit has functioned on a marginal basis since, in some vehicles, the available vacuum head during panic stop was barely sufficient to draw back the diaphragm and thus the piston to relieve the brake fluid pressure far enough to open the pressure switch. This function is required to reset the anti-skid system. It was stated that presently 14.5 to 15 inches of Hg is required to accomplish this. However, this vacuum level requirement should be dependent on the initial pressure required to achieve locked wheels under the particular test conditions; i. e., the captured brake fluid pressure. It was estimated that possibly one out of twenty tests show a lag (longer-than-normal stopping distance) that may be attributed to this marginal behavior.

The rotary valve was stated to be effective only toward the end of its rotary motion during which it should be transferring the vacuum to the Perma-Vac unit. In this part of its rotary motion a large change in output resulted from small angular rotation. It appears to be intended for the rotary valve to vary the vacuum level and thus the brake fluid pressure as a continuous function of the governor speed (wheel speed) within the speed range of the governor. It apparently does not accomplish this function.

There is no data which will show that the governor is functioning in a smooth, continuous manner within its speed range. There is only proof that it functions as a source of angular momentum to act on the cam gear at wheel lock-up and in fact can be fooled in conjunction with the cam gear and inertial switch by gradual application of brake pressure through the "slipping speed" to a "skid" condition. The "slipping speed" is the range of speed between the speed of the wheel corresponding with the forward motion of the vehicle and locked wheel condition or "skid" condition. Thus it is presently possible to generate a skid without initiating the Perma Anti-Skid Control; when wheels are locked gradually rather than suddenly.

The Perma pressure switch has been modified to function with reasonable accuracy and repeatibility.

Some of the recorded data obtained on test runs with the vehicles were examined. Attention was drawn to the almost uniform time period between pulses as indicated by the brake fluid pressure. This behavior suggests that there is a built-in limit of response time of some component in the system forcing the aforementioned cycling between the locked-wheel pressure switch setting. A reduced period between pulses (greater repetition rate) has been observed under wet road conditions which can be explained by the reduced excursion of brake fluid pressure.

2. Are the components universal in applicability to the vehicles in use and to future models of vehicles?

No, not in the present design configuration. The present design is not applicable to the following:

- Manual shift transmissions
- Disc brakes
- Front wheel drives
- Front wheel speedometer take-offs
- Other than 12-volt electrical systems.

In addition, the present design has demonstrated some satisfactory results in dual brake systems, but has been unsatisfactory in single brake systems which are presently the standard.

Application to future models of vehicles creates a hazy picture. Automotive manufacturers' products are fraught with economic and competitive changes. The most that can be stated here based on present day trends is that functional design of an anti-skid control system should not be critically dependent on vacuum levels and should be compatible with higher brake fluid pressures.

Also, see discussion of question 3 below..

3. What adaptors to vehicle differences exist in the product kits?

The gear box is available with adapters to the transmission speedometer take-off for all new GM cars. However, on American, Ford, and Chrysler cars the speedometer take-off gear is part of the flexible drive cable and requires cutting into the cable. The gearing is not an exact duplicate in all cases and in some applications changes the speedometer calibration.

The Perma-Vac piston is available in two sizes. One unit 0.5 inch diameter for single brake line systems. Two units 0.343 inch diameter each for dual brake systems.

4. What other adaptors have been found necessary or to be desired for the system to function in diverse installations; i.e., vehicle models where the original Perma system fails to function?

The only item referred to was the experimental restriction check valve ("metering" valve) that has been tried on single brake line systems but is generally undesirable, because of the limited fluid flow in a brake system and danger of obstructing the release of pressure from the wheel cylinders.

5. Have the later adaptors been designed, tested and proved satisfactory?

No.

6. Are all components functioning for all road conditions, speeds and environmental conditions?

Testing of the system over the full range of these conditions has not been completed. Some of the conditions not covered thus far are the following:

Environmental - low temperatures
- high altitude driving
- humidity effects.

Road conditions - icy and slushy roads
- elevation grades or hilly roads.

Speeds - low speeds, 5-15 miles per hour, 15-25 miles per hour.
(There is the possibility of excessive free wheeling at the lowest speeds.)

General - Corrosion (none apparent to date)
- Shelf life of hardware.

RELIABILITY:

1. Have the reliabilities of all the components been determined?

The gear box is considered acceptable.

The sensor unit has been run for 40,000 miles thus far and appears to survive this test. However, there are reliability questions inherent in the design which have not been answered.

(a) Is the expansion spring on the governor mounted and guided in such a manner as to prohibit the spring interfering with the return of the governor extension shaft?

(b) Is there an unvented cavity between the telescoping extension shaft and the main governor shaft which may result in a damping action, particularly if oil gets on the shaft?

(c) A statement was made that the valve mechanical design and the valve leverage appears to be an unreliable design.

(d) The spring return of the solenoid is close to the spring force value of the governor expansion spring. Will the solenoid-return spring over-ride a sticky valve?

Memo to: J. W. Homberg



(c) The Perma project people raised the question of the reliability of the can gear in the sensor. They seem to feel it may be possible to lock it in the position which would initiate the Perma Control any time the pressure switch was closed.

2. Is the anti-skid system fail-safe? (i.e., does every possible failure in the system restore normal brake control to the driver?)

The present Perma anti-skid control is not fail-safe. A failure of the vacuum in the present configuration results in a differential force on the diaphragm in the Perma-Vac unit of only that created by the spring. This force sets an upper limit on the brake fluid pressure that the driver can apply with the brake pedal. The limited pressure is much smaller than that which the driver could apply if the Perma Control was not connected to the brake system, probably less than 50%.

Specific Questions if not Covered in the Above Items:

1. (Reliability) What is the effect of loss of vacuum (due to leaks, stalled engine, etc.) on original brake system capabilities?

See question 2 above.

2. (Functional) Does reset of the Perma Control occur at approximately 10 mph in a positive manner with any reasonable accuracy? Is system returned to standard braking?

These questions could not be answered. Tests of the control system in vehicles have been limited to speeds of 30, 50 and 70 mph. The answer to these questions would seem to be very important since the low speed is related to bumper-to-bumper driving in traffic and the reset response time becomes a greater percentage of overall Perma Control time.

J. A. Lundin

JV A. Lundin
Development Department 500

cc: Messrs. B. C. Person
A. Rozel
C. R. Odermann

SINGER

MEMORANDUM

RECEIVED

FEB 19 1956

BURTON C. PERSON

TO: Mr. B. C. Person

FROM: A. Romel

DATE: February 17, 1956

SUBJECT: Trip Report to Ford Motor Company

Personnel Contacted:

A. Sampson - Senior Engineer (Advanced Chassis Department)

J. Ihnacik - Principal Engineer (Senior Project Engineer)

W. Hallahan - Brake Engineer

It was apparent at the beginning of our discussion that the above representatives were not fully informed as to the purpose of my visit or the role I would play in the test program. They had been laboring under the impression that I was to be present during the instrumentation and testing phases to review their methods and ensure that the test was conducted to our satisfaction. They were unaware of the fact that an installation was to be made during my visit and stated that it generally takes several weeks to set up a test.

I assured them that Singer had the highest regard as to their ability and integrity, and therefore, it was not our intent to take part in the instrumentation or testing of the device. Furthermore, that we would appreciate their professional opinion as to its merit and would not challenge it. I indicated that I would come out when the tests were conducted if they felt that I could be of some assistance.

We discussed the modifications made to the unit by Singer briefly and in general terms only. I was asked why we wanted a test run and told them that we had only performed tests on dry and wet road surfaces with the new unit. I also told them that the new design had not been tested on a Ford product and that our test facilities were rather limited, especially for low coefficient of friction road testing.

A discussion of the metering concept followed, in which, Mr. Ihnacik indicated that he felt we should limit the pressure drop to approximately 125 p.s.i. to shorten the cycle rather than bringing the pressure down to zero. I stated that our tapes showed a minimum pressure of about 200 p.s.i. when the unit was cycling. After learning this, he stated that the valve would not be necessary. In fact, he was of the opinion that it might cause a problem on low coefficient of friction road surfaces. He then talked about the possibility of modifying the unit before testing, such as, adding a vacuum reserve tank and valving arrangement to isolate the front drums from the system.

He then proposed that we conduct a full set of tests on a 1965 Ford before turning over the unit to them for testing in that, a second negative test result would kill any future prospects. I explained our position as to wanting an evaluation of the present configuration before trying the arrangements he proposed. He agreed to go along with our request.

I learned that Kelsey Hayes had a device under development which was being evaluated by them. Also, that they were not developing a device of their own at this time, but were looking at several other devices. One device, I was told, was similar to ours with the exception that a second sensing device was used to sense linear deceleration, in addition to, angular deceleration of the rear wheels. This second sensor is the pendulum type.

Mr. Ihnacik commented on the violent action of our unit and its possible detrimental effect on the suspension system and back-up plates. He also informed me that pumping the front wheels was not necessary, in that, straight panic stopping was their primary objective. This would cut down the violent reaction somewhat, and also take full advantage of the higher brake distribution on the front wheels. Stopping distance in their opinion is also of utmost importance and they would not tolerate any increase over the conventional brake system.

Their criteria for evaluating stability is based on a panic stop with hands off the wheel. This gives them a common reference point when comparing test runs. My guess is that Kelsey Hayes also uses the standard, and explains why they found no advantage in regards to stability when using our device. We did not use this method during our tests and therefore, stability was not recognized as a problem. Some steering correction was used by our test driver on most of the runs.

As far as using vacuum for a power source is concerned, Mr. Ihnacik indicated that they had no reservations and that in all probability the first device offered to the public would use this source. He also stated that at a later date, a hydraulic system like power steering would probably be used. The use of a vacuum reserve tank was mentioned as a possible safety precaution against vacuum drops. He confirmed our findings that vacuum drops during panic or high deceleration stops were to be expected.

As far as disc brakes and dual master cylinders are concerned, they expect to introduce these rather quickly in the next few years. Discs are to be expected on all four wheels and the anti-skid device introduced would probably be for rear disc brakes to take advantage of its low fade characteristics and resistance to lock-up. Apparently, discs do not lock-up as suddenly as drum brakes do. This certainly would effect the ability of our inertia sensing mechanism to detect lock-up and would increase the driver's ability to "fool" our unit.

The minimum number of cycles per second needed for stability during panic stops was stated to be 10 cycles/sec. by Mr. Ihnacik. We fall far short of this requirement.

The following points were agreed upon in regards to the evaluation of our device.

1. The unit would be tested in its present state on all four wheels first.

2. It will be tried with and without the metering valves.

3. Rear wheel actuation only will be tried.

4. A preliminary evaluation of the modifications made will be conducted during the time interval of acquiring and instrumentation of a test vehicle. An assessment as to whether these modifications would improve the performance over that which was observed on the earlier unit would be made during this time. This assessment would determine how much testing and instrumentation would be done. In any event, the unit will be performance tested.

5. The addition of a vacuum reserve tank and/or any other modifications which they want to try will be done after the above tests have been completed. Mr. Ihnacik will let me know when the test schedule has been established.

A. Romel

A. Romel
Supervisory Engineer
Central Engineering Division

AR:ms

DEFENDANT'S EXHIBIT 560 FOR IDENTIFICATION

SINGER

30 ROCKEFELLER PLAZA • NEW YORK 20, N.Y.

MEMORANDUM

TO: Mr. C. F. Druder

FROM: B. C. Person

DATE: February 25, 1966

REFER TO:

SUBJECT: PERMA ANTI-SKID CONTROL

On February 10, 1966, we forwarded to you a copy of the information reviewed with Mr. Karcher in the meeting to get his agreement on the next steps in our relation with Perma. The attached material is a draft of the highlights of the subsequent meeting between Singer and Perma representatives.

Subsequent to this meeting, I had had a phone call from Mr. Perrino of Perma with the following results:

1. We are still at an impasse in regard to any overall settlement agreement.

2. Perma has rejected our proposal for conducting a retrieval program and refused to submit a counterproposal.

Original Signed by
B. C Person

BCP:lk
Att.

cc: Mr. A. di Scipio <— Int'l copy for

RECEIVED
FEB 25 1966
Alfred di Scipio

#560

DRAFT

[DX 560 for id, p 2]

SUMMARY OF MEETING WITH PERMA

FEBRUARY 16, 1966

The meeting with Perma on February 16, 1966, resulted in somewhat better results that we anticipated:

1. Although agreement was not reached on an overall settlement, the door for further discussion is still partially open.
2. Agreement on the bases for retrieving the units in the New England area is progressing. Both parties are in agreement on the basic plan and have talked about the details of how a retrieval would be conducted.

Settlement Agreement

The discussion regarding a bases for an overall settlement agreement between Perma and Singer ended with the following proposal by Singer on the table:

1. Resale of the patent application and rights to the U.S. and Canada for $385,000 (plus any amounts owed as a result of the retrieval program discussed below).
   - $20,000 cash down payment.
   - Payment of the balance over a period of time (probably tied to the sale of the units). A specific proposal in this area must be developed.
2. Singer will agree to a value of $600,000 on the inventory of anti-skid components, but retains absolute right to refuse to sell the components except to a third party that meets Singer's approval. (If Perma should interest a company of stature, such as Bendix, we believe the inventory could be sold with adequate protection to Singer's name.)

Mr. Perrino indicated it was impossible for Perma to proceed on this basis,

primarily because of the restriction on the inventory; and, secondly, because there was no money for a down payment. We indicated we could not move from our position regarding absolute control over the inventory.

Retrieval Program

Agreement was reached on the principal points of a program to retrieve the Perma Anti-Skid units still in the field in the New England area. A detailed plan needs to be completed and put into writing. Also, Mr. Perrino was to check with counsel on one point of the agreement - splitting the payment for Class II items.

The understanding to date is:

1. The costs of the retrieval program will be split as follows: Singer will pay for Class III units and one-half of the Class II units; Perma will pay for Class I units and one-half of the Class II units.
2. Singer will advance the funds required for the retrieval; Perma will pay for their share of the program by increasing the amount of the outstanding note held by Singer. Thus, reimbursement to Singer may be postponed to as late as December, 1969.
3. The agreement will contain a clause that the program is entered into without prejudice to the rights of either party.
4. Customers are to be reimbursed in cash, not with a promise of a new unit.
5. Perma will mail a letter to the customers which has been reviewed and approved by Singer.
6. Perma will remove the units at their facility in North Attleboro, Massachusetts.

BCP:lk
2/17/66

1916-P2
(21)

DEFENDANT'S EXHIBIT 658 FOR IDENTIFICATION

CHECKED BY D. Barry
DELIVERED BY Lee Fredericks
DATE May 16, 1973
TIME 9

Re: Perma v. Singer

Paul R. DeRensis, Esq.
Poletti Freidin Prashker
Feldman & Gartner
777 Third Avenue
New York, New York 10017

Dear Mr. DeRensis:

Herewith please find, pursuant to your request, one unit of the Perma anti-skid device.

The unit is made available to you upon the condition, accepted by you on September 23, 1971, that it will be used only in connection with the instant action and will not be used in such a manner as to risk bodily harm or injury to any person.

Very truly yours,

Samuel S. Linderman

Enclosures

SSL:bc

cc: Messrs. Chanler
Clark
Gordon

COPY

1966-P2
(2)

DEFENDANT'S EXHIBIT 659 FOR IDENTIFICATION

CHECKED BY
DELIVERED BY
DATE May 22, 1973
TIME

Re: Perma v. Singer

Paul R. DeRensis, Esq.
Poletti Freidin Prashker
Feldman & Gartner
777 Third Avenue
New York, New York 10017

Dear Mr. DeRensis:

Pursuant to your request, herewith please find one unit of the Perma anti-skid device.

The unit includes static kit serial No. 2314, adaptor kit No. PRM-307 and a variable kit for a V-8 model Chevrolet produced from 1961 through 1962. It replaces the unit sent to you on May 16, 1973, which you found unsuitable for your purposes.

The unit is made available to you upon the condition, accepted by you on September 23, 1971, that it will be used only in connection with the instant action and will not be used in such a manner as to risk bodily harm or injury to any person.

I would be grateful if you return the unit sent to you last week to our messenger.

Very truly yours,

Samuel S. Linderman

Enclosures
bcc: William C. Chanler, Esq.
Merrell E. Clark, Jr., Esq.
Phillip Cordon, Esq.

DEFENDANT'S EXHIBIT 684 FOR IDENTIFICATION

KELSEY-HAYES COMPANY
ROMULUS, MICHIGAN

June 6, 1974

Mr. Jonathan K. Lagemann
Winthrop, Stimson, Putnam & Roberts
40 Wall Street
New York, N.Y. 10005

Dear Mr. Lagemann:

On a number of previous occasions you have repeatedly requested that we produce our Mr. Every to testify on behalf of Singer in connection with your pending lawsuit on the Perma Anti-Skid System. It is my understanding that you intend to use Mr. Every's testimony to establish a foundation sufficient to introduce a test report written by Mr. Every on 3 February 1966 into evidence.

Kelsey-Hayes will agree to produce Mr. Every to testify for the aforementioned purpose provided the following conditions are met:

i.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to any test procedure any test or any test results utilized, conducted or formulated in connection with any anti-skid braking system other than the so-called Perma Anti-Skid Braking System.

ii.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to the identification, function, design or performance of any anti-skid braking system other than the so-called Perma Anti-Skid Braking System.

iii.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to any communication, contract, license or other business relationship between Kelsey-Hayes and its customers, suppliers, licensees, licensors or contractors.

KELSEY-HAYES COMPANY



iv.) The court will not permit questions to be directed to Mr. Every which elicit or are intended to elicit identification of or information regarding any of Kelsey-Hayes' customers, suppliers, contractors, licensees, licensors or any development, testing, consulting or design activity Kelsey-Hayes has done therefor or therewith.

v.) Singer will submit to Kelsey-Hayes in writing the questions to be asked of Mr. Every for Kelsey-Hayes prior approval.

We feel the above limitations are necessary in view of the confidential nature of information within Mr. Every's personal knowledge. We also feel that the limitations will not preclude Mr. Every from accurately relating to the court the circumstances and conditions under which he conducted the test discussed in his 3 February 1966 memorandum and hence laying the foundation for such memorandum to be placed into evidence.

As we discussed you will seek to obtain the concurrence of the court to limit Mr. Every's testimony as set forth herein.

Very truly yours,

Henry J. Policinski
Patent Attorney

HJP/es

[Ct X 1, p 1]

COURT'S EXHIBIT 1

1966-P2 (2)

file T.L. Taylor TH-13 Criminal Antitrust Files


POLETTI FREIDIN PRASHKER FELDMAN & GARTNER

777 THIRD AVENUE

NEW YORK, N. Y. 10017

AREA CODE 212 888-2200

CABLES-POLETFRE

CHARLES POLETTI COUNSEL

1888 FREIDIN (1900-1966)

MARTIN N. FELDMAN
MAX B. FRANK
LARRY GARTNER
HAL B. GRAND
HERBERT MORRIS
MILTON H. MOSS
ROBERT PRASHKER
THEODORE PROPP
LAWRENCE M. REILLY
MAX F. ROSENFELD
GEORGE J. SOLOMON


November 30, 1973

Jonathan K. Lagemann, Esq.
Winthrop, Stimson, Putnam & Roberts
40 Wall Street
New York, New York

Re: Perma Research & Development Co. v. The Singer Co., United States District Court, Southern District of New York, 66 Civ. 665

Dear Cord:

On November 27, 1973, we agreed that plaintiff and defendant would, insofar as possible, set forth in letter form one week in advance of the testimony of their respective expert witnesses, the anticipated subject matter of that testimony. Pursuant to that agreement and by way of repetition of our disclosures to you on November 27, I set forth below the anticipated subjects which will be covered by the testimony of Daniel Goor, plaintiff's first expert witness:

1. Competitive anti-skid devices, their technical features and development, with emphasis on the Kelsey Hayes unit;

2. The criteria for marketability of an anti-skid device;

3. Steps necessary to render marketable an unperfected anti-skid device;

4. Whether the Perma anti-skid device was or could have been made marketable and, if not, the modifications necessary to make it marketable;

5. Sales of anti-skid devices manufactured by others.

Mr. Goor's testimony will be based upon his prior professional experience including his familiarity with other

Ct. Ex. 1
12/14/73



[Ct X 1, p p]

[redacted] [Ct X 1, p 2]

LETTI FREIDIN PRASHKER FELDMAN & GARTNER

Jonathan K. Lagemann, Esq. 2 November 30, 1973

anti-skid devices and relevant literature in the field, his evaluation of the Perma anti-skid device based upon physical models, simulated operation, drawings, prints and schematics of the device and Singer's documents reflecting its evaluation thereof.

Sincerely yours,

Paul R. Grand

PRG:ch

COURT'S EXHIBIT 5
PAGE 6 (PAGE 1 OF EXHIBIT A TO COURT'S EXHIBIT 5)

Exhibit A
Page 1 of 12

| Mfr. | Car Line | Model Year 1969 Total Production | 1969 Anti-Skid (Percent) | 1969 Anti-Skid (Number) | 1970 Total Production | 1970 Anti-Skid (Percent) | 1970 Anti-Skid (Number) | 1971 Total Production | 1971 Anti-Skid (Percent) | 1971 Anti-Skid (Number) | 1972 Total Production | 1972 Anti-Skid (Percent) | 1972 Anti-Skid (Number) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ford | Mark III/IV | 22,564 | 7.5% | 1,692 | 21,432 | 100.0% | 21,432 | 27,091 | 100.0% | 27,091 | 48,591 | 100.0% | 48,591 |
| | Thunderbird | 49,272 | 0.3 | 148 | 50,364 | 2.2 | 1,108 | 36,055 | 7.3 | 2,632 | 54,695 | 5.8 | 3,173 |
| | Lincoln | N.O. | - | - | 37,695 | 9.9 | 3,732 | 35,551 | 8.5 | 3,021 | 45,969 | 7.8 | 3,586 |
| | Mercury | N.O. | - | - | N.O. | - | - | N.O. | - | - | 174,154 | 0.9 | 1,567 |
| | Other Ford | 2,073,092 | - | - | 1,926,720 | - | - | 2,043,140 | - | - | 2,309,676 | - | - |
| | Total Ford | 2,144,928 | 0.1% | 1,840 | 2,036,211 | 1.3% | 26,272 | 2,141,037 | 1.5% | 32,744 | 2,631,085 | 3.2% | 56,916 |
| GM | Toronado | N.O. | - | - | 25,475 | 1.8 | 459 | 29,265 | 6.6% | 1,931 | 48,900 | 2.8% | 1,369 |
| | Cadillac | N.O. | - | - | N.O. | - | - | N.O. | - | - | 227,713 | 1.0 | 2,277 |
| | El Dorado | N.O. | - | - | 23,842 | 0.6 | 143 | 27,368 | 4.3 | 1,177 | 40,074 | 6.0 | 2,404 |
| | Other GM | 4,415,511 | - | - | 4,046,102 | - | - | 3,499,630 | - | - | 4,309,556 | - | - |
| | Total GM | 4,415,511 | 0% | 0 | 4,095,419 | 0.01% | 602 | 3,556,263 | 0.1% | 3,108 | 4,626,243 | 0.1% | 6,050 |
| Chrysler | Imperial | N.O. | - | - | N.O. | - | - | 11,432 | 2.4% | 263 | 35,784 | 4.0% | 633 |
| | Other Chrysler | 1,479,459 | - | - | 1,311,073 | - | - | 1,244,827 | - | - | 1,295,409 | - | - |
| | Total Chrysler | 1,479,459 | 0% | 0 | 1,311,073 | 0% | 0 | 1,256,259 | 0.02% | 763 | 1,331,193 | 0.05% | 633 |
| | Total 3 Manufacturers | 8,039,898 | 0.02% | 1,840 | 7,442,703 | 0.4% | 26,874 | 6,954,359 | 0.5% | 36,115 | 8,589,501 | 0.7% | 63,599 |

[Ct X 5, p 6]

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[Ct X 5, p 6 (continued)]

| 1973 | | | 1974 (To 3/31/74) | | | Totals | | |
|---|---|---|---|---|---|---|---|---|
| Total Production | Anti-Skid (Percent) | Anti-Skid (Number) | Total Production | Anti-Skid (Percent) | Anti-Skid (Number) | Total Production | Anti-Skid (Percent) | Anti-Skid* (Number) |
| 69,437 | 100.0% | 69,437 | 43,529 | 100.0% | 43,529 | 332,644 | 91.0% | 311,772 |
| 82,711 | 5.9 | 4,880 | 42,752 | 7.4 | 3,164 | 315,849 | 4.8 | 15,154 |
| 58,635 | 7.0 | 4,104 | 31,179 | 8.9 | 2,775 | 209,029 | 8.2 | 17,218 |
| 184,359 | 1.4 | 2,581 | 67,709 | 2.6 | 1,760 | 426,222 | 1.4 | 5,973 |
| 2,393,978 | - | - | 1,359,870 | - | - | 12,105,450 | - | - |
| 2,788,124 | 2.9% | 81,002 | 1,545,039 | 3.7% | 57,228 | 13,269,294 | 1.5% | 311,772 |
| | | | | | | | | |
| 56,226 | 3.2% | 1,799 | 25,416 | 3.3% | 839 | 185,282 | 3.5% | 6,537 |
| 251,176 | 1.5 | 3,768 | 133,458 | 2.0 | 2,669 | 612,347 | 1.4 | 8,716 |
| 51,451 | 5.6 | 2,881 | 31,488 | 6.2 | 1,952 | 174,223 | 4.9 | 8,557 |
| 5,227,855 | - | - | 2,656,411 | - | - | 24,135,045 | - | - |
| 5,566,708 | 0.2% | 8,448 | 2,846,773 | 0.2% | 5,460 | 25,106,917 | 0.09% | 23,810 |
| | | | | | | | | |
| 15,667 | 3.8% | 596 | N.O. | - | - | 42,893 | 3.3% | 1,431 |
| 1,570,181 | - | - | 803,753 | - | - | 7,724,692 | - | - |
| 1,585,848 | 0.04% | 596 | 803,753 | 0% | 0 | 7,767,585 | 0.02% | 1,431 |
| | | | | | | | | |
| 9,940,680 | 0.9% | 90,046 | 5,195,565 | 1.1% | 56,688 | 46,163,706 | 0.6% | 275,141 |

* Note:

| | Total 1969-74 Units | Percent of Total A/E | Percent of Total Production |
|---|---|---|---|
| Anti-Skid as Standard Equipment | 211,772 | 77% | 0.46% |
| Anti-Skid as Optional Equipment | 63,389 | 23 | 0.14 |
| Total | 275,161 | 100% | 0.60% |

E-1346

COURT'S EXHIBIT 6

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

- - - - - - - - - - - - - - - - - - - - x

PERMA RESEARCH & DEVELOPMENT COMPANY,

Plaintiff,

- against -

THE SINGER COMPANY,

Defendant.

- - - - - - - - - - - - - - - - - - - - x

66 Civ. 665 (KTD)

STIPULATION OF FACTS

IT IS HEREBY STIPULATED AND AGREED by and between the undersigned attorneys as follows:

1. General Motors Corporation, Chrysler Corporation and Ford Motor Company have marketed anti-skid devices as indicated below.

· Ford Motor Company

| Car Line | Model Years Offered |
|---|---|
| Mark III/IV | 1969-1974 (Standard Equipment) |
| Thunderbird | 1969-1974 (Optional Equipment) |
| Lincoln Continental | 1970-1974 (Optional Equipment) |
| Mercury | 1972-1974 (Optional Equipment) |

· The General Motors Corporation

| Car Line | Model Years Offered |
|---|---|
| Oldsmobile Toronado | 1971-1974 (Optional Equipment) |
| Cadillac | 1972-1974 (Optional Equipment) |
| Cadillac El Dorado | 1971-1974 (Optional Equipment) |

· Chrysler Corporation

| Car Line | Model Years Offered |
|---|---|
| Imperial | 1971-1973 (Optional Equipment) |

(a) The General Motors Corporation device marketed as optional equipment on Oldsmobile Toronado, Cadillac and

Cadillac El Dorado model automobiles is supplied by a division of General Motors Corporation. Anti-skid prices[1] on the 1974 models are $214.00 for El Dorado and Cadillac, and $190.00 for Toronado.

(b) The Chrysler Corporation device was supplied to Chrysler by The Bendix Corporation. This device is no longer offered on any Chrysler Corporation automobiles effective with the 1974 models. The price[1] for the Chrysler Imperial anti-skid device at the end of the 1973 model year was $348.50.

(c) The Ford Motor Company device is supplied by The Kelsey-Hayes Corporation. Anti-skid prices[1] for the 1974 Ford models are: Thunderbird $196.60, Mercury $196.90 and Lincoln Continental $214.70.

2. Attached hereto as Exhibit "A" are copies of the appropriate Ward's Automotive Reports for model years 1969 through March 31, 1974, which set forth the number of new cars produced by General Motors Corporation, Ford Motor Company and Chrysler Corporation for this period and the number of anti-skid devices installed thereon for the model years 1972 to March 31, 1974.

3. The number of new cars produced by General Motors Corporation, Ford Motor Company and Chrysler Corporation and the number of anti-skid units installed thereon during the model years 1969 through 1971 are set forth in Exhibit "B" attached hereto.

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[1] Price listed is the manufacturer's suggested retail price in effect during the model year. These prices are supplied by the automobile manufacturer with a disclaimer stipulation such as that supplied by Ford Motor Company: "The manufactuer's suggested retail prices are suggested prices only and are not intended to determine the prices charged by dealers to their customers on resale." The price of options included as standard equipment is part of the base price of the vehicle.

4. When executed by the attorneys for the parties herein, the facts set forth herein and the Ward's Automotive Reports attached hereto may be relied on by the parties in the same manner and to the same extent as any other fact or exhibit in evidence.

Dated: New York, New York
June 24, 1974

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER

By _____
A Member of the Firm
Attorneys for Plaintiff
Office and P.O. Address:
777 Third Avenue
New York, New York 10017

WINTHROP, STIMSON, PUTNAM & ROBERTS

By _____
A Member of the Firm
Attorneys for Defendant
Office and P.O. Address:
40 Wall Street
New York, New York 10005

[Ct X 6, p 5]

# Percent of Factory Installed Equipment on U.S. '69 Model Cars

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power Drum Brakes | Front Wheel Disc Brakes | Power Door Locks | 2-Way Power Seats | 4-6 Way Power Seats | Power Side Windows | Power Tailgate Windows | '69 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 98.0 | 0.4 | 50.3 | 45.4 | 4.3 | 84.2 | 3.9 | 1.8 | ... | 91.7 | 31.5 | 11.0 | 1.5 | ... | 2.0 | 4.5 | 11.5 | 1,109,639 |
| [illegible] | 20.7 | 72.4 | 25.7 | 74.3 | ... | ... | 97.7 | ... | ... | 56.6 | ... | 42.5 | ... | ... | ... | 26.8 | ... | 25,427 |
| [illegible] | 72.4 | 11.9 | 48.7 | 40.4 | 10.9 | 85.1 | 3.0 | 2.5 | ... | 72.7 | 10.7 | 21.0 | 0.2 | ... | ... | 0.9 | 5.1 | 458,827 |
| [illegible] | 93.6 | 5.5 | 24.8 | 9.9 | 62.9 | 79.3 | 0.9 | 0.5 | ... | 38.8 | 2.2. | 7.8 | ... | ... | ... | ... | ... | 268,011 |
| [illegible] | 72.4 | 13.0 | ... | ... | 100.0 | 80.4 | 2.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 6,625 |
| [illegible] | 57.6 | 23.9 | 45.8 | 39.2 | 15.0 | 86.6 | 3.6 | 2.8 | ... | 57.3 | 6.7 | 29.0 | ... | ... | ... | 1.4 | ... | 205,213 |
| [illegible] | 55.7 | ... | 100.0 | ... | ... | 85.0 | 7.6 | 2.5 | 7.3 | 90.3 | 53.8 | 41.0 | 4.4 | ... | 8.4 | 15.5 | 13.2 | 389,418 |
| [illegible] | 99.1 | 0.6 | 100.0 | ... | ... | 64.7 | 33.9 | 2.1 | ... | 99.7 | ... | 50.9 | 9.5 | ... | 17.6 | 53.5 | ... | 112,436 |
| [illegible] | 83.3 | 10.5 | 25.1 | 63.1 | 11.8 | 89.7 | 5.2 | 3.4 | 3.5 | 88.9 | 22.5 | 26.7 | 0.4 | ... | 1.1 | 2.7 | 2.8 | 284,234 |
| [illegible] | 78.1 | 13.5 | ... | 85.8 | 14.2 | 82.6 | 6.2 | 3.7 | 5.5 | 85.4 | 20.3 | 21.8 | ... | ... | 1.2 | 3.5 | ... | 73,241 |
| [illegible] | 93.9 | ... | 77.3 | 22.7 | ... | 78.1 | 18.9 | 4.2 | 21.9 | 99.8 | 81.9 | 13.3 | 9.5 | 9.8 | 24.4 | 33.4 | ... | 369,870 |
| [illegible] | 100.0 | ... | 92.2 | 7.8 | ... | 47.9 | 51.0 | 13.4 | 61.1 | 100.0 | 46.8 | 53.2 | 22.0 | ... | 80.9 | 83.9 | ... | 22,434 |
| [illegible] | 93.4 | 4.9 | 82.1 | 15.5 | 2.4 | 87.0 | 9.0 | 3.6 | 4.4 | 95.4 | 63.9 | 10.7 | 1.7 | ... | 3.5 | 6.3 | 16.6 | 239,259 |
| [illegible] | 100.0 | ... | 68.6 | 31.4 | ... | 78.3 | 19.6 | 3.6 | 20.5 | 99.7 | 92.2 | 3.9 | 9.7 | 1.3 | 31.4 | 37.3 | ... | 423,369 |
| [illegible] | 100.0 | ... | 59.7 | 0.3 | ... | 45.5 | 48.9 | 10.2 | 29.5 | 100.0 | 88.8 | 11.2 | 15.0 | ... | 73.5 | 87.3 | ... | 29,872 |
| [illegible] | 97.3 | 0.9 | 35.8 | 60.2 | 4.0 | 80.6 | 6.5 | 2.0 | 4.7 | 95.3 | 51.5 | 3.4 | 1.9 | ... | 3.8 | 6.0 | 13.9 | 185,515 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 24.3 | 31.1 | 41.2 | 93.6 | 100.0 | ... | 100.0 | 67.3 | 5.4 | 93.1 | 100.0 | ... | 156,524 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 9.5 | 16.1 | 74.3 | 99.9 | 100.0 | ... | 100.0 | 80.0 | 2.8 | 97.2 | 100.0 | ... | 23,333 |
| Tot. GM Units | 3,953,493 | 193,222 | 2,639,590 | 1,413,103 | 356,034 | 3,492,810 | 454,506 | 218,936 | 482,235 | 3,871,559 | 1,712,530 | 1,011,535 | 318,573 | 52,790 | 585,146 | 784,616 | 273,542 | 4,415,511 |
| % Total Output | 50.6 | 4.4 | 59.8 | 32.1 | 8.1 | 79.1 | 10.3 | 5.0 | 11.0 | 87.7 | 38.8 | 22.9 | 7.2 | 1.2 | 13.2 | 17.8 | 6.2 | |
| [illegible] | 93.0 | 0.1 | 41.2 | 56.9 | 1.9 | 85.0 | 8.9 | 2.3 | ... | 91.7 | 2.0 | 62.9 | 1.7 | ... | 3.7 | 4.5 | 20.2 | 685,353 |
| [illegible] | 86.6 | 4.6 | 25.3 | 61.5 | 13.2 | 85.5 | 2.5 | ... | ... | 71.8 | ... | 25.3 | ... | ... | 0.3 | 0.5 | 6.0 | 389,988 |
| [illegible] | 70.5 | ... | ... | 29.8 | 70.2 | 70.6 | ... | ... | ... | 30.9 | ... | 3.5 | ... | ... | ... | ... | 6.9 | 65,071 |
| [illegible] | 48.4 | ... | ... | ... | 100.0 | 69.4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 48,618 |
| [illegible] | 71.1 | 11.7 | 26.9 | 54.7 | 18.4 | 82.1 | 4.8 | 4.2 | ... | 65.9 | ... | 30.5 | ... | ... | ... | ... | ... | 203,824 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 43.9 | 39.8 | 16.3 | 34.4 | 100.0 | ... | 100.0 | 40.4 | ... | 59.7 | 86.6 | ... | 49,272 |
| [illegible] | 59.7 | ... | 100.0 | ... | ... | 73.5 | 17.3 | 7.1 | 7.7 | 99.6 | ... | 91.3 | 9.9 | ... | 25.9 | 26.7 | 22.6 | 140,516 |
| [illegible] | 92.4 | 1.8 | 7.8 | 79.1 | 13.1 | 90.5 | 3.6 | ... | ... | 82.9 | ... | 34.7 | ... | ... | 0.9 | 1.5 | 6.6 | 117,421 |
| [illegible] | 93.3 | 3.1 | 100.0 | ... | ... | 20.3 | 11.3 | 5.6 | ... | 92.4 | ... | 53.9 | ... | ... | ... | 6.3 | ... | 100,572 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 34.2 | 41.7 | 21.6 | 99.6 | 100.0 | ... | 100.0 | 79.6 | 4.8 | 95.2 | 100.0 | ... | 19,316 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 12.1 | 59.2 | 28.5 | 99.8 | 100.0 | ... | 100.0 | 83.1 | 3.7 | 96.3 | 100.0 | ... | 22,514 |
| Tot. Ford Units | 1,929,552 | 57,753 | 902,626 | 1,012,459 | 229,533 | 1,763,561 | 174,922 | 71,232 | 88,448 | 1,770,116 | 18,002 | 1,038,655 | 97,902 | 2,688 | 158,963 | 190,551 | 207,825 | 2,144,978 |
| % Total Output | 50.0 | 2.7 | 42.0 | 47.3 | 10.7 | 82.2 | 8.2 | 3.3 | 4.1 | 82.5 | 0.8 | 50.8 | 4.6 | 0.1 | 7.4 | 8.9 | 9.6 | |
| [illegible] | 59.6 | | 60.1 | 29.7 | 1.8 | 87.3 | 2.1 | 2.0 | ... | 95.9 | 43.8 | 8.8 | 1.6 | ... | 2.2 | 2.5 | 14.6 | 383,713 |
| [illegible] | 75.4 | 20.9 | 87.3 | 5.4 | 7.3 | 83.9 | 2.4 | 3.9 | ... | 67.4 | 6.5 | 4.3 | ... | ... | ... | 0.6 | 6.2 | 224,257 |
| [illegible] | 83.4 | 11.6 | 56.8 | 20.8 | 22.4 | 88.1 | 5.5 | ... | ... | 61.8 | 6.0 | 8.8 | ... | ... | ... | ... | ... | 25,372 |
| [illegible] | 83.9 | 0.2 | 6.6 | 1.3 | 92.1 | 71.0 | ... | ... | ... | 37.8 | 1.6 | 2.4 | ... | ... | ... | ... | ... | 73,331 |
| [illegible] | 55.8 | ... | 48.1 | 51.9 | ... | 83.3 | 3.6 | 2.8 | ... | 97.6 | 66.1 | 11.1 | 3.6 | ... | 5.7 | 6.0 | 15.2 | 125,553 |
| [illegible] | 87.7 | 8.4 | 83.6 | 10.0 | 6.4 | 86.9 | 1.8 | 1.8 | ... | 82.6 | 12.4 | 8.2 | ... | ... | ... | 0.5 | 9.5 | 168,164 |
| [illegible] | 92.1 | 2.8 | 57.6 | 41.9 | 0.5 | 81.2 | 6.6 | 8.6 | ... | 90.5 | 44.5 | 18.8 | ... | ... | ... | 5.1 | ... | 84,124 |
| [illegible] | 88.4 | 7.1 | 29.4 | 6.0 | 64.6 | 81.5 | 1.7 | ... | ... | 57.1 | 2.3 | 2.6 | ... | ... | ... | ... | ... | 153,539 |
| [illegible] | 59.9 | ... | 59.0 | 10.0 | ... | 78.4 | 11.5 | 8.4 | 18.3 | 99.8 | 54.0 | 30.7 | 9.5 | ... | 25.5 | 27.9 | 10.1 | 226,711 |
| [illegible] | 100.0 | ... | 100.0 | ... | ... | 25.2 | 41.8 | 32.7 | 99.7 | 100.0 | ... | 100.0 | 68.2 | ... | 95.1 | 100.0 | ... | 20,018 |
| Tot. Chrysler Units | 1,345,697 | 84,497 | 969,104 | 271,175 | 219,179 | 1,226,378 | 57,800 | 55,351 | 20,111 | 1,[illegible]19 | 443,613 | 180,591 | 45,309 | ... | 91,295 | 94,495 | 123,553 | 1,479,459 |
| % Tot. Output | 91.0 | 5.7 | 66.9 | 18.3 | 14.8 | 82.9 | 3.9 | 3.7 | 2.4 | 82.8 | 30.0 | 12.2 | 3.1 | ... | 6.2 | 6.4 | 8.4 | |
| American Motors | 79.6 | 4.5 | 2.8 | 53.1 | 44.1 | 63.6 | 2.0 | 1.[illegible] | ... | 53.7 | 27.6 | 8.2. | ... | ... | ... | 1.4 | 6.8 | 245,462 |
| Tot. AMC Units | 195,197 | 11,051 | 6,819 | 130,552 | 103,681 | 150,055 | 4,955 | 2,904 | ... | 148,552 | 67,919 | 20,153 | ... | ... | ... | 3,438 | 16,677 | |
| Tot. Industry Units | 7,470,324 | 346,523 | 4,538,139 | 2,827,709 | 913,727 | 6,639,403 | 692,323 | 348,423 | 620,794 | 7,010,546 | 2,242,064 | 2,300,937 | 461,784 | 55,478 | 835,[illegible] | 1,073,100 | 621,537 | 8,225,380 |
| % Total Output | 50.2 | 4.2 | 54.8 | 34.2 | 11.0 | 80.1 | 8.4 | 4.2 | 7.5 | 84.6 | 27.1 | 27.8 | 5.6 | 0.6 | 10.1 | 13.0 | 7.5 | |

NOTE: [illegible] installation rates are based on cars built in both U.S. and Canada for sale in the U.S. only. A pr[illegible] date of July 31, 1969, was set for Corvette, Camaro and Fire[illegible] than the '69 model run for these three lines on calendar year basis December of calendar year 1969. Marstuk production is through July 31, 1969. Ford Motor [illegible] include 7,770 Mark III cars built prior to Aug. 1, 1968.

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# Percent of Factory Installed Equipment on U.S. '69 Model Cars

| | Bucket Seating | Vinyl Roof | White Sidewall Tires | Tinted Windshield | Tinted Windshield & Other Windows | Air Conditioning | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Column | Speed Regulating Devices | SW Luggage Rack | Reclining Front Seats | Dual Exhausts | '69 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 24 | 37.2 | 66.4 | 3.8 | 70.8 | 62.1 | 4.9 | 14.2 | 60.3 | | 2.5 | 14.2 | 22.1 | 6.4 | 1.8 | 6.7 | ... | 3.4 | 1,102,659 |
| Corvette | 100.0 | 9.2 | | | 89.5 | 29.9 | 94.8 | ... | 24.1 | 100.0 | | 100.0 | | 27.2 | ... | ... | ... | 100.0 | 25,557 |
| Chevelle | 15.9 | 33.8 | 52.6 | 0.9 | 60.5 | 34.3 | 14.5 | ... | 49.4 | ... | 25.0 | ... | 20.1 | 2.1 | ... | 2.6 | ... | 19.3 | 428,737 |
| Nova | 4.4 | 17.9 | 45.2 | 1.6 | 31.5 | 11.2 | 7.0 | ... | 38.1 | ... | 7.0 | ... | 4.8 | ... | ... | ... | ... | 7.5 | 269,011 |
| Camaro | 54.0 | | 54.6 | 0.1 | 25.8 | | 7.8 | 54.0 | 13.4 | ... | ... | ... | 10.9 | 2.6 | ... | ... | ... | 10.9 | 6,320 |
| Camaro | 100.0 | 41.1 | 47.5 | 1.2 | 47.2 | 19.1 | 21.0 | ... | 46.2 | ... | 19.2 | ... | 21.7 | 3.0 | ... | ... | ... | 26.1 | 200,213 |
| Firebird | 0.2 | 45.2 | 92.3 | 22.9 | 64.8 | 74.4 | 7.7 | 31.3 | 62.0 | ... | 2.6 | 35.5 | 18.5 | 13.9 | 5.2 | 6.0 | 0.2 | 24.5 | 322,419 |
| Grand Prix | 92.7 | 85.5 | 95.2 | 15.5 | 78.1 | 83.2 | 21.6 | 52.8 | 10.3 | ... | 36.9 | 100.0 | | 37.0 | 10.5 | ... | 3.5 | 100.0 | 112,155 |
| Tempest | 55.2 | 44.9 | 79.1 | 31.3 | 40.1 | 45.4 | 13.8 | ... | 66.4 | ... | 22.4 | ... | 25.2 | 3.3 | 0.5 | 1.3 | 0.5 | 27.0 | 281,244 |
| Firebird | 92.0 | 42.5 | 65.0 | 35.7 | 28.3 | 31.1 | 12.9 | ... | 53.4 | ... | 30.8 | ... | 23.7 | 6.5 | 0.6 | ... | ... | 21.6 | 73,141 |
| Cutlass | 1.9 | 67.0 | 54.1 | 23.9 | 68.7 | 80.2 | 8.1 | 74.1 | 28.8 | ... | ... | 37.8 | 18.3 | 22.1 | 6.6 | ... | ... | 0.8 | 369,970 |
| Toronado | 7.2 | 85.5 | 95.4 | 6.6 | 91.2 | 95.2 | ... | ... | 55.3 | ... | 16.1 | 100.0 | | 67.2 | 19.2 | ... | ... | 100.0 | 28,194 |
| F-85 | 25.3 | 33.3 | 83.0 | 20.0 | 57.2 | 66.9 | 11.0 | ... | 70.7 | ... | 16.1 | ... | 19.9 | 6.1 | 1.5 | 8.1 | ... | 4.6 | 233,203 |
| Buick | 0.7 | 65.6 | 93.3 | 23.3 | 70.6 | 79.8 | 7.9 | 79.8 | 15.9 | ... | 2.6 | 37.4 | 30.6 | 25.3 | 11.0 | ... | 0.1 | 1.9 | 423,939 |
| Riviera | 28.7 | 89.9 | 96.0 | 7.9 | 89.6 | 94.9 | 18.5 | 42.6 | 5.0 | ... | 52.4 | 100.0 | | 100.0 | 19.5 | ... | 4.8 | 100.0 | 52,872 |
| Special | 6.7 | 41.1 | 88.1 | 34.2 | 52.7 | 64.0 | 6.1 | ... | 78.5 | ... | 8.8 | ... | 37.6 | 9.7 | 1.8 | 9.5 | 0.3 | 6.9 | 183,913 |
| Olds 88 | | 72.1 | 58.9 | ... | 93.0 | 97.2 | 12.8 | 100.0 | | ... | ... | 100.0 | | 51.7 | 21.0 | ... | ... | | 159,634 |
| Eldorado | 2.7 | 52.0 | 59.5 | | 93.3 | 99.5 | | 100.0 | | ... | ... | 100.0 | | 78.6 | 36.0 | ... | ... | | 23,333 |
| GMC Units | 776,597 | 2,075,518 | 3,322,893 | 601,575 | 2,796,300 | 2,648,567 | 441,558 | 1,197,378 | 2,060,179 | 25,867 | 427,684 | 1,034,178 | 863,483 | 611,616 | 197,407 | 149,402 | 8,624 | 656,304 | 4,415,511 |
| % Tot. Output | 17.6 | 47.0 | 75.3 | 13.6 | 63.3 | 60.0 | 10.0 | 27.1 | 45.7 | 0.6 | 9.7 | 23.4 | 19.6 | 13.9 | 4.5 | 8.4 | 0.2 | 14.9 | |
| Ford | 2.0 | 30.9 | 79.4 | 5.8 | 62.6 | 64.3 | 4.0 | 27.7 | 47.5 | ... | ... | 28.2 | 11.8 | 2.9 | 1.6 | 12.9 | 1.8 | 2.2 | 505,343 |
| Fairlane | 10.2 | 23.3 | 80.9 | 1.5 | 35.5 | 27.3 | 7.9 | 8.9 | 33.8 | 22.3 | 1.9 | ... | 11.7 | ... | ... | 4.0 | ... | 14.3 | 255,911 |
| Falcon | 9.0 | 3.5 | 43.7 | 0.9 | 32.5 | 15.1 | ... | 5.0 | 41.0 | ... | ... | ... | ... | ... | ... | 4.4 | ... | NA | 65,071 |
| Maverick | | | 55.8 | | | 12.2 | | | 77.4 | ... | ... | ... | ... | ... | ... | ... | ... | NA | 43,618 |
| Mustang | 59.4 | 16.1 | 84.6 | 0.5 | 38.3 | 23.2 | 8.6 | 30.1 | 29.9 | 26.9 | 0.6 | 23.0 | 4.4 | 3.2 | 0.2 | ... | ... | 23.2 | 293,524 |
| Thunderbird | 34.0 | 88.0 | 95.1 | | 88.8 | 89.0 | 9.0 | 69.4 | 30.6 | ... | | 100.0 | | 67.2 | 15.2 | ... | 11.1 | 100.0 | 49,272 |
| Mercury | 2.8 | 46.9 | 92.8 | 4.0 | 80.7 | 76.0 | 6.4 | 51.3 | 30.7 | 3.7 | 0.5 | 56.3 | 7.9 | 18.7 | 7.8 | 18.0 | 4.8 | 11.8 | 140,516 |
| Montego | 5.1 | 23.5 | 85.6 | 4.3 | 45.1 | 40.1 | 3.5 | ... | 63.6 | ... | 1.4 | ... | 11.7 | | | 4.9 | ... | 9.3 | 117,421 |
| Cougar | 98.3 | 54.1 | 93.8 | 3.1 | 57.0 | 53.3 | 3.9 | 58.1 | 28.1 | ... | 3.2 | 27.8 | 9.6 | 9.5 | 1.1 | ... | ... | 21.9 | 100,022 |
| Lincoln | 4.9 | 83.6 | 58.9 | | 93.5 | 99.3 | 13.7 | 81.2 | 18.8 | ... | ... | 100.0 | | 49.7 | 29.1 | ... | 16.8 | 100.0 | 39,315 |
| Mark III | | 53.6 | 97.3 | | 93.9 | 99.8 | 19.9 | 100.0 | | ... | ... | 100.0 | | 76.1 | 48.1 | ... | 34.1 | 100.0 | 22,564 |
| Ford Units | 480,675 | 654,312 | 1,752,514 | 72,954 | 1,158,660 | 1,076,213 | 122,276 | 592,485 | 872,696 | 167,679 | 14,242 | 568,543 | 196,571 | 140,244 | 56,968 | 164,101 | 42,222 | 320,816 | 2,144,928 |
| % Tot. Output | 22.4 | 31.0 | 81.7 | 3.4 | 54.0 | 50.2 | 5.7 | 27.6 | 40.7 | 7.8 | 0.7 | 26.5 | 9.2 | 6.5 | 2.7 | 7.6 | 2.0 | 14.1 | |
| Fury | 4.5 | 30.6 | 76.3 | 23.0 | 55.2 | 67.0 | 6.2 | 7.6 | 65.5 | ... | 0.1 | 70.7 | 1.0 | 1.6 | 1.7 | 6.9 | 1.7 | 5.4 | 393,213 |
| Belvedere | 22.7 | 24.6 | 85.5 | 30.5 | 28.0 | 28.3 | 27.6 | ... | 51.2 | ... | 18.3 | | 4.7 | ... | 0.5 | 3.9 | ... | 40.8 | 224,357 |
| Barracuda | 70.3 | 29.6 | 84.3 | 29.7 | 25.9 | 21.7 | 16.6 | ... | 77.9 | ... | 0.4 | | 6.3 | ... | ... | ... | ... | 20.8 | 25,472 |
| Valiant | 1.2 | 9.3 | 52.5 | 22.3 | 12.1 | 16.0 | 2.5 | ... | 57.4 | ... | | | | | | | | | 29,331 |
| Polara | 6.0 | 43.0 | 86.6 | 18.5 | 65.6 | 70.9 | 7.6 | 13.2 | 79.2 | ... | 0.1 | | 30.7 | 4.0 | 6.3 | 8.9 | 7.7 | 13.8 | 126,550 |
| Coronet | 17.2 | 40.9 | 84.3 | 27.4 | 36.5 | 39.6 | 12.5 | ... | 73.2 | ... | 6.4 | 14.1 | 4.7 | | 0.9 | 5.7 | ... | 22.0 | 181,104 |
| Charger | 100.0 | 87.8 | 96.3 | 26.1 | 50.7 | 50.5 | 21.9 | ... | 73.6 | ... | 19.9 | 100.0 | ... | ... | 2.5 | ... | ... | 42.7 | 84,104 |
| Dart | 12.7 | 35.1 | 70.1 | 25.8 | 17.6 | 23.1 | 8.9 | ... | 60.1 | ... | 0.1 | | | | | | | 13.8 | 163,539 |
| Chrysler | 9.8 | 55.2 | 93.4 | 13.2 | 78.5 | 80.4 | 10.0 | 90.8 | 9.2 | ... | | 19.2 | 32.4 | 8.0 | 11.3 | 7.4 | 17.2 | 10.0 | 226,711 |
| Imperial | 12.2 | 99.0 | 98.5 | | 98.8 | 98.9 | 24.1 | 100.0 | | ... | | 100.0 | | 60.9 | 50.5 | | 79.0 | | 20,018 |
| Chrysler Units | 254,154 | 610,202 | 1,214,605 | 240,937 | 533,737 | 758,052 | 182,857 | 268,925 | 822,720 | ... | 70,318 | 416,270 | 137,157 | 40,961 | 56,345 | 71,147 | 70,581 | 257,824 | 1,479,459 |
| % Tot. Output | 17.2 | 41.3 | 82.1 | 23.0 | 36.1 | 51.2 | 12.4 | 18.2 | 55.6 | | 4.8 | 28.1 | 9.3 | 2.8 | 3.8 | 4.8 | 4.8 | 17.4 | |
| American Mtrs. | 27.2 | 15.8 | 53.8 | 19.1 | 30.1 | 38.9 | 11.1 | 28.9 | 28.4 | ... | 5.0 | 14.4 | 18.7 | 9.1 | 2.7 | 15.3 | 43.7 | 10.2 | |
| Tot. AMC Units | 54,790 | 35,555 | 144,829 | 47,182 | 76,245 | 95,667 | 27,237 | 71,135 | 70,097 | ... | 12,280 | 35,542 | 46,122 | 22,423 | 6,692 | 37,739 | 120,045 | 25,144 | 246,452 |
| Tot. Indus. Units | 1,565,126 | 3,339,027 | 6,434,842 | 1,063,651 | 4,563,032 | 4,578,709 | 773,978 | 2,129,923 | 3,825,692 | 193,546 | 524,724 | 2,054,533 | 1,243,333 | 815,274 | 317,412 | 422,369 | 241,432 | 1,242,033 | 8,286,360 |
| % Tot. Output | 18.9 | 40.9 | 77.7 | 12.8 | 55.1 | 55.3 | 9.3 | 25.7 | 46.2 | 2.3 | 6.3 | 24.8 | 15.0 | 9.8 | 3.8 | 5.1 | 2.9 | 15.0 | |

N.A. At Chrysler Corp. data on sales are based on cars built in both U.S. and Canada for sale in the U.S. only. A production cutoff date of July 31, 1969, was set for Corvette, Camaro and Firebird when the '69 model run for these three lines was extended into November-December of calendar year 1969. Mustang production is through July 31, 1969. Ford Motor Co. totals do not include 1,770 Mark III cars built prior to Aug. 1, 1968.

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E-1352

# Percent of Factory Installed Equipment on U.S. '70 Model Cars

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio Alone | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power Drum Brakes | Front Wheel Disc Brakes | Power Door Locks | 2-Way Power Seats | 4-6 Way Power Seats | Power Side Windows | Power Tailgate Windows | '70 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 97.9 | ... | 63.9 | 33.6 | 2.5 | 87.1 | 5.2 | 2.2 | ... | 95.2 | 16.2 | 44.3 | 2.0 | ... | 2.5 | 4.7 | 14.3 | 831,135 |
| Corvette | 93.5 | 70.5 | 98.4 | 61.6 | ... | ... | 98.1 | ... | ... | 98.8 | ... | 98.9 | ... | ... | ... | 27.8 | ... | 10,816 |
| Chevelle | 98.6 | 9.8 | 44.9 | 49.6 | 6.5 | 89.6 | 3.9 | 4.5 | ... | 82.5 | 9.1 | 31.6 | 1.0 | ... | ... | 1.2 | 5.6 | 446,016 |
| Nova | 72.1 | 5.3 | 31.4 | 12.8 | 55.1 | 85.5 | 1.1 | 1.3 | ... | 50.1 | 2.4 | 8.2 | ... | ... | ... | ... | ... | 219,172 |
| Monte Carlo | 95.5 | 1.0 | 49.6 | 51.4 | ... | 81.6 | 13.0 | 8.2 | ... | 99.3 | ... | 100.0 | 0.7 | ... | 0.7 | 10.7 | ... | 140,814 |
| Camaro | 73.1 | 15.0 | 45.1 | 44.8 | 10.1 | 83.7 | 6.9 | ... | ... | 74.2 | ... | 147.7 | ... | ... | ... | ... | ... | 239,911 |
| Pontiac | 99.9 | ... | 100.0 | ... | ... | 82.4 | 14.1 | 2.6 | ... | 99.5 | 32.0 | 56.9 | 6.0 | 0.2 | 8.4 | 18.4 | 15.2 | 485,496 |
| Grand Prix | 99.2 | 0.5 | 100.0 | ... | ... | 90.3 | 38.2 | 7.4 | ... | 99.8 | ... | 100.0 | 7.8 | ... | 16.0 | 55.0 | ... | 61,782 |
| Tempest | 88.7 | 6.8 | 17.4 | 75.4 | 7.2 | 87.8 | 7.3 | 3.3 | ... | 98.0 | 23.5 | 30.9 | 0.7 | ... | 1.1 | 2.7 | 3.9 | 421,216 |
| Firebird | 80.3 | 9.0 | 61.3 | 32.8 | 6.4 | 85.2 | 12.2 | 5.3 | ... | 92.1 | ... | 163.0 | 1.0 | ... | ... | 4.7 | ... | 49,158 |
| Oldsmobile | 100.0 | .... | 85.0 | 15.0 | ... | 80.0 | 17.0 | 4.0 | ... | 100.0 | ... | 99.0 | 12.0 | 3.0 | 33.0 | 41.0 | ... | 291,735 |
| Cutlass | 100.0 | ... | 79.0 | 21.0 | ... | 45.0 | 54.0 | 15.0 | ... | 100.0 | ... | 100.0 | 26.0 | ... | 89.0 | 92.0 | ... | 56,748 |
| F-85 | 98.0 | 3.0 | 75.0 | 23.0 | 2.0 | 89.0 | 6.0 | 4.0 | ... | 97.0 | 42.0 | 38.0 | 2.0 | ... | 3.0 | 7.0 | 13.0 | 314,073 |
| Delmont | 100.0 | .... | 71.5 | 28.5 | ... | 72.4 | 25.5 | 3.6 | ... | 99.9 | 91.1 | 6.7 | 13.6 | 0.4 | 38.5 | 38.4 | 6.2 | 420,744 |
| Firenza | 100.0 | ... | 100.0 | ... | ... | 40.0 | 53.6 | 10.4 | ... | 100.0 | 80.4 | 10.6 | 21.3 | ... | 76.5 | 89.5 | ... | 37,668 |
| Skylark | 97.7 | 1.1 | 27.8 | 69.3 | 2.9 | 88.7 | 7.6 | 1.8 | ... | 98.1 | 48.8 | 5.6 | 1.3 | ... | 2.4 | 4.4 | 4.4 | 221,868 |
| Buick | 100.0 | .... | 100.0 | ... | ... | ... | 44.3 | *55.4 | ... | 100.0 | ... | 100.0 | 77.0 | 4.3 | 96.7 | 100.0 | ... | 249,053 |
| Electra | 100.0 | .... | 100.0 | ... | ... | ... | 16.4 | *83.5 | ... | 100.0 | ... | 100.0 | 83.0 | 2.0 | 99.0 | 100.0 | ... | 51,942 |
| Total GM Units | 3,828,227 | 123,755 | 2,559,433 | 1,266,516 | 268,574 | 3,211,684 | 524,910 | 302,535 | ... | 3,738,093 | 994,814 | 1,421,177 | 347,651 | 21,106 | 574,750 | 770,191 | 282,075 | 4,598,429 |
| % Total Output | 83.5 | 3.0 | 62.5 | 30.9 | 6.6 | 78.4 | 12.8 | 7.4 | ... | 91.3 | 24.3 | 44.5 | 8.5 | 0.5 | 14.0 | 19.8 | 6.9 | |
| Ford | 98.9 | ... | 94.4 | 4.6 | 1.0 | 84.6 | 6.6 | 1.9 | ... | 98.9 | 2.5 | 73.4 | 8.1 | ... | 3.6 | 4.6 | 14.7 | 917,028 |
| Falcon (Torino) | 87.5 | 3.7 | 23.4 | 59.7 | 16.9 | 87.1 | 2.8 | ... | ... | 77.9 | ... | 30.4 | ... | ... | 0.6 | 1.1 | 5.4 | 229,715 |
| Fairlane | 81.9 | ... | ... | 10.4 | 89.6 | 80.5 | ... | ... | ... | 23.0 | ... | ... | ... | ... | ... | ... | 5.2 | 156,614 |
| Maverick | 86.4 | ... | ... | ... | 100.0 | 82.1 | ... | ... | ... | 7.1 | ... | ... | ... | ... | ... | ... | ... | 269,183 |
| Mustang | 74.6 | 11.2 | 25.2 | 50.8 | 15.0 | 89.1 | 4.0 | 4.6 | ... | 72.9 | ... | 35.2 | ... | ... | ... | ... | ... | 261,962 |
| Thunderbird | 100.0 | ... | 100.0 | ... | ... | 33.0 | 50.3 | 16.7 | ... | 100.0 | ... | 100.0 | 46.6 | ... | 64.6 | 83.7 | ... | 87,312 |
| Mercury | 99.9 | ... | 42.6 | 57.4 | ... | 69.3 | 20.3 | 6.6 | 10.1 | 98.2 | ... | 92.0 | 11.8 | ... | 28.5 | 28.5 | 12.5 | 168,503 |
| Montego | 96.5 | 2.9 | 13.4 | 73.6 | 13.0 | 89.6 | 4.6 | ... | ... | 88.1 | ... | 42.1 | ... | ... | 1.0 | 1.9 | 5.4 | 120,972 |
| Cougar | 93.2 | 2.8 | 100.0 | ... | ... | 77.0 | 13.8 | 7.0 | ... | 93.6 | ... | 67.6 | ... | ... | ... | 5.9 | ... | 72,036 |
| Marquis | 100.0 | .... | 100.0 | ... | ... | 28.4 | 55.2 | 18.0 | 59.6 | 100.0 | ... | 100.0 | 21.4 | 3.9 | 55.1 | 100.0 | ... | 37,056 |
| Park Lane | 100.0 | ... | 100.0 | ... | ... | 6.5 | 69.5 | 23.9 | 99.9 | 100.0 | ... | 100.0 | 97.9 | **3.4 | 35.6 | 100.0 | ... | 21,132 |
| Tot. Ford Units | 1,832,015 | 38,552 | 1,145,997 | 511,819 | 378,354 | 1,659,920 | 176,037 | 59,080 | 73,955 | 1,616,268 | 20,469 | 1,092,236 | 107,582 | 2,199 | 161,003 | 195,000 | 180,728 | 2,056,211 |
| % Total Output | 90.8 | 1.9 | 56.8 | 25.1 | 18.9 | 81.5 | 8.6 | 2.9 | 3.6 | 79.4 | 1.0 | 53.6 | 5.3 | 0.1 | 7.9 | 9.3 | 9.9 | |
| Ford | 98.9 | ... | 55.3 | 42.4 | 1.3 | 82.8 | 2.6 | 1.9 | ... | 96.9 | 41.3 | 20.0 | 1.5 | ... | 2.3 | 2.6 | 13.8 | 287,727 |
| Galaxie | 82.9 | 12.0 | 84.0 | 6.6 | 9.4 | 82.7 | 2.5 | 4.0 | ... | 76.7 | 9.0 | 9.8 | ... | ... | ... | 0.5 | 6.7 | 103,735 |
| LTD | 72.4 | 18.5 | 56.3 | 33.7 | 12.0 | 82.9 | 4.9 | 8.7 | ... | 69.9 | 6.6 | 13.2 | ... | ... | ... | 2.1 | ... | 95,439 |
| Torino | 78.9 | 3.1 | 27.5 | ... | 72.5 | 84.0 | ... | ... | ... | 42.7 | 1.6 | 2.1 | ... | ... | ... | ... | ... | 22,553 |
| Ranchero | 99.7 | ... | 55.1 | 44.8 | 0.1 | 78.7 | 5.6 | 2.6 | ... | 99.4 | 58.7 | 24.4 | 3.9 | ... | 6.4 | 7.9 | 14.2 | 61,024 |
| Country | 91.7 | 5.5 | 92.2 | 9.9 | 9.9 | 86.4 | 2.0 | 1.9 | ... | 86.3 | 11.4 | 9.9 | ... | ... | ... | 0.5 | 9.5 | 121,915 |
| Custom | 91.3 | 7.4 | 61.4 | 38.1 | 0.5 | 80.6 | 7.2 | 10.1 | ... | 94.7 | 38.4 | 19.7 | ... | ... | ... | 4.6 | ... | 49,718 |
| Club Wagon | 91.9 | 2.6 | 30.3 | ... | 69.7 | 88.3 | ... | ... | ... | 67.3 | 1.6 | 1.5 | ... | ... | ... | ... | ... | 46,761 |
| Econoline | 77.1 | 12.7 | 69.0 | 29.6 | 13.4 | 81.5 | 6.5 | 7.6 | ... | 74.8 | 8.8 | 19.1 | ... | ... | ... | 3.3 | ... | 61,772 |
| Cruiser | 99.9 | ... | 59.4 | 9.6 | ... | 73.4 | 12.7 | 11.7 | 12.3 | 90.8 | 52.2 | 30.1 | 11.7 | ... | 27.3 | 29.1 | 9.3 | 122,777 |
| Truck | 100.0 | .... | 100.0 | ... | ... | 19.3 | 35.8 | 44.8 | 100.0 | 100.0 | ... | 100.0 | 75.1 | ... | 99.5 | 100.0 | ... | 11,816 |
| Tot. Chrysler Units | 1,159,435 | 5,517 | 793,525 | 400,495 | 259,461 | 1,064,971 | 57,366 | 58,617 | 34,052 | 1,040,908 | 323,637 | 213,214 | 37,623 | ... | 72,700 | 86,255 | 89,242 | 1,311,073 |
| % Total Output | 88.2 | 0.05 | 60.9 | 30.5 | 19.6 | 81.2 | 4.4 | 4.5 | 2.6 | 80.0 | 24.7 | 16.3 | 2.8 | ... | 5.6 | 6.6 | 6.8 | |
| AMC | 42.0 | 80.0 | 100.0 | ... | ... | 62.4 | 11.7 | 13.5 | ... | 69.7 | 4.3 | 82.2 | ... | ... | ... | ... | ... | 4,116 |
| Rebel | 91.5 | 2.7 | 3.9 | 42.9 | 40.0 | 54.5 | 1.1 | ... | ... | 50.4 | 16.9 | 6.0 | ... | ... | ... | ... | 9.2 | 47,656 |
| Hornet | 67.3 | ... | ... | 7.3 | 83.7 | 43.3 | ... | ... | ... | 23.4 | 2.2 | 2.0 | ... | ... | ... | ... | ... | 6,543 |
| AMX | 99.2 | ... | 82.4 | 10.1 | 7.5 | 77.2 | 4.2 | 1.2 | ... | 80.7 | 61.9 | 12.1 | ... | ... | ... | ... | 14.7 | 10,154 |
| Gremlin | 72.5 | 8.4 | ... | 70.7 | 16.2 | 71.9 | 2.7 | 2.7 | ... | 70.4 | 21.5 | 22.1 | ... | ... | ... | ... | ... | 10,154 |
| Javelin | 22.7 | ... | ... | ... | 100.0 | 66.6 | ... | ... | ... | 11.6 | 3.0 | ... | ... | ... | ... | ... | ... | 6,543 |
| Total AMC Units | 131,159 | 6,331 | 55,240 | 56,274 | 120,785 | 143,720 | 4,388 | 2,079 | ... | 125,904 | 64,523 | 21,699 | ... | ... | ... | 2,224 | 13,353 | 285,614 |
| % Total Output | 78.0 | 2.5 | 22.8 | 23.4 | 49.8 | 59.2 | 1.8 | 0.9 | ... | 51.9 | 22.5 | 9.0 | ... | ... | ... | 0.6 | 3.6 | |
| Total Industry Units | 7,017,544 | 174,855 | 4,549,397 | 2,235,634 | 1,024,154 | 6,080,275 | 762,701 | 422,491 | 108,007 | 6,330,273 | 1,392,453 | 3,148,326 | 492,856 | 23,305 | 808,453 | 1,040,765 | 565,442 | 7,618,357 |
| % Total Output | 92.3 | 2.3 | 59.3 | 29.1 | 11.6 | 79.1 | 9.9 | 5.5 | 1.4 | 83.0 | 18.1 | 41.0 | 6.4 | 0.3 | 10.5 | 13.6 | 7.3 | |

Note A. Chrysler Corp. installation rates are based on cars built both in U.S. and Canada for sale in the U.S. only. '70 model output of Corvette, Camaro and Firebird did not begin until early 1970. *Cadillac and Eldorado were equipped with stereo tape as installed at stereo tape. **Where fitted a split bench seat that was 2-way on the passenger side and 2-way on the driver side. †Were equipped with standard front disc brakes as '70½ models. Maverick includes '69 and '70 models. Falcon is '70 model through Dec. 5, 1969. Mercury is North American industry.

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WARD'S AUTOMOTIVE REPORTS 37

[Ct X 6, p 7]

E-1353

# Percent of Factory Installed Equipment on U.S. '70 Model Cars (Continued)

| | Bucket Seating | Vinyl Roof | White Sidewall Tires | Tinted Windshield | Tinted Windshield & Other Windows | Air Conditioning | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Column | Speed Repeating Devices | SW Luggage Rack | Reclining Front Seats | Dual Exhausts | '70 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | ... | 35.3 | 82.9 | 6.5 | 73.4 | 71.8 | 4.5 | 13.5 | 55.5 | ... | 4.3 | 13.5 | 19.5 | 8.5 | 2.0 | 8.5 | ... | 4.6 | 831,135 |
| Corvette | 100.0 | 4.8 | 84.2 | ... | 100.0 | 38.5 | 100.0 | ... | 22.0 | 100.0 | ... | 100.0 | ... | 33.5 | ... | ... | ... | 100.0 | 17,316 |
| Chevelle | 16.9 | 38.2 | 83.1 | 1.9 | 63.8 | 45.7 | 10.9 | ... | 49.4 | ... | 25.7 | ... | 13.4 | 3.2 | 0.1 | 3.0 | ... | 17.4 | 443,245 |
| Nova | 3.9 | 18.0 | 63.5 | 1.1 | 34.0 | 14.3 | 6.2 | ... | 36.5 | ... | 12.4 | ... | 3.5 | ... | ... | ... | ... | 7.5 | 318,122 |
| Monte Carlo | 16.9 | 81.1 | 56.8 | 1.9 | 77.0 | 69.4 | 10.9 | ... | 38.8 | ... | 20.6 | 100.0 | ... | 16.2 | 0.1 | ... | ... | 11.4 | 145,960 |
| Camaro | 100.0 | 34.5 | 91.6 | ... | 57.1 | 30.9 | 15.8 | ... | 61.5 | ... | 12.2 | ... | 12.4 | 5.4 | ... | ... | ... | 17.0 | 220,931 |
| Firebird | ... | 45.7 | 92.5 | 22.4 | 63.3 | 82.1 | 7.2 | 33.7 | 56.1 | ... | 5.3 | 39.5 | 14.4 | 13.2 | 8.3 | 8.3 | ... | 6.2 | 130,476 |
| Grand Prix | 69.1 | 87.6 | 95.4 | 11.3 | 84.4 | 91.2 | 9.7 | 35.9 | 9.0 | ... | 59.1 | 100.0 | ... | 20.1 | 9.7 | ... | 1.8 | 10.0 | 66,750 |
| Tempest | 42.8 | 42.5 | 85.2 | 32.7 | 44.5 | 57.5 | 9.7 | ... | 65.1 | ... | 23.4 | ... | 20.9 | 2.4 | 1.0 | 2.1 | 0.3 | 13.0 | 210,439 |
| Firebird | 100.0 | 24.0 | 91.7 | 31.2 | 41.0 | 45.9 | 10.8 | 21.1 | 28.6 | 6.6 | 38.5 | ... | 17.4 | 5.3 | ... | ... | ... | 22.4 | 48,738 |
| Catalina | 1.0 | 71.0 | 96.0 | 20.0 | 74.0 | 86.0 | 7.0 | 77.0 | 23.0 | ... | ... | 37.0 | 19.0 | 25.0 | 9.0 | ... | ... | ... | 256,745 |
| Tornado | 7.0 | 91.0 | 96.0 | 7.0 | 91.0 | 97.0 | ... | ... | 62.0 | ... | ... | 100.0 | ... | 73.0 | 28.0 | ... | ... | 100.0 | 25,475 |
| Ninety-Eight | 25.0 | 45.0 | 83.0 | 28.0 | 55.0 | 67.0 | 10.0 | ... | 69.0 | ... | 18.0 | ... | 20.0 | 6.0 | 2.0 | 7.0 | ... | 18.0 | 210,273 |
| Buick | 0.4 | 68.3 | 95.5 | 19.0 | 76.0 | 85.6 | 8.0 | 72.8 | 21.8 | ... | 3.4 | 37.3 | 30.7 | 27.6 | 13.8 | 9.0 | ... | 6.1 | 432,744 |
| Riviera | 27.7 | 87.5 | 95.7 | 6.7 | 91.5 | 96.9 | 18.1 | 38.3 | 4.2 | ... | 57.6 | 100.0 | ... | 100.0 | 25.7 | ... | ... | 100.0 | 67,035 |
| Eighty-Eight | 6.8 | 48.6 | 89.2 | 35.7 | 47.3 | 63.2 | 5.3 | ... | 73.0 | ... | 14.3 | ... | 19.7 | 7.5 | 1.1 | 2.6 | ... | 11.0 | 226,421 |
| Cadillac | ... | 78.7 | 95.3 | ... | 98.3 | 98.4 | 10.9 | *100.0 | ... | ... | ... | 100.0 | ... | 63.3 | 20.2 | ... | ... | ... | 214,913 |
| Eldorado | 1.9 | 94.0 | 99.2 | ... | 99.5 | 99.7 | ... | 100.0 | ... | ... | ... | 100.0 | ... | 87.2 | 37.5 | ... | ... | ... | 23,842 |
| Tot. GM Units | 571,635 | 1,970,765 | 3,579,767 | 533,617 | 2,817,225 | 2,725,282 | 342,881 | 1,030,536 | 1,811,944 | 20,533 | 483,521 | 1,025,383 | 636,351 | 525,948 | 208,957 | 165,477 | 1,824 | 498,789 | 4,055,419 |
| % Tot. Output | 14.0 | 48.1 | 87.4 | 13.2 | 68.8 | 66.5 | 8.3 | 25.2 | 44.2 | 0.5 | 11.8 | 25.0 | 15.5 | 12.8 | 5.1 | 4.0 | .004 | 12.2 | |
| Ford | 1.2 | 34.9 | 78.1 | 7.3 | 64.6 | 71.7 | 3.8 | 25.8 | 40.5 | ... | ... | 21.6 | 11.2 | 3.3 | 2.2 | 13.3 | 1.7 | 1.4 | 827,323 |
| Fairlane (Torino) | 9.0 | 21.0 | 75.6 | 2.0 | 43.7 | 41.6 | 6.4 | 2.6 | 45.8 | ... | 2.7 | ... | 8.9 | ... | ... | 3.9 | ... | ... | 326,710 |
| Falcon | ... | ... | 61.5 | 0.2 | 17.6 | 9.6 | ... | ... | 43.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 15,824 |
| Maverick | ... | 6.3 | 70.5 | ... | 31.5 | 18.9 | ... | ... | 73.9 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 285,535 |
| Mustang | 100.0 | 19.1 | 78.9 | 2.6 | 37.9 | 28.2 | 10.6 | 32.3 | 48.7 | ... | 4.1 | 28.6 | 4.7 | 2.5 | ... | ... | ... | 14.2 | 134,787 |
| Thunderbird | 37.4 | 69.6 | 96.7 | ... | 93.8 | 93.7 | 9.4 | 75.4 | 24.6 | ... | ... | 100.0 | ... | 71.5 | 20.7 | ... | 14.1 | 100.0 | 91,364 |
| Mercury | 1.2 | 61.9 | 92.8 | 3.5 | 81.8 | 83.8 | 9.5 | 50.9 | 32.1 | ... | 1.0 | 55.6 | 6.0 | 20.4 | 9.8 | 16.2 | 8.1 | ... | 138,505 |
| Montego | 11.9 | 37.4 | 79.6 | 5.2 | 47.1 | 49.5 | 5.3 | 14.7 | 51.2 | ... | 2.7 | ... | 12.6 | ... | ... | 4.6 | ... | 11.1 | 125,672 |
| Cougar | 100.0 | 69.7 | 95.6 | ... | 83.9 | 81.7 | 5.1 | 30.9 | 57.7 | ... | 3.3 | 30.9 | 9.8 | 12.1 | ... | ... | ... | 11.9 | 72,305 |
| Lincoln | ... | 91.5 | 98.4 | ... | 99.6 | 99.6 | 14.5 | 79.9 | 20.1 | ... | ... | 100.0 | ... | 60.4 | 40.3 | ... | 21.6 | ... | 37,335 |
| Mark III | ... | 100.0 | 99.6 | ... | 99.9 | 99.9 | ... | 17.9 | 100.0 | ... | ... | 100.0 | ... | 33.9 | 55.0 | ... | 34.7 | 100.0 | 21,432 |
| Tot. Ford Units | 335,400 | 681,824 | 1,633,079 | 81,032 | 1,063,003 | 1,146,475 | 103,391 | 480,925 | 1,004,438 | ... | 23,250 | 443,291 | 157,764 | 147,215 | 76,070 | 149,243 | 46,560 | 130,660 | 2,035,211 |
| % Tot. Output | 16.5 | 33.5 | 80.2 | 4.0 | 52.2 | 56.3 | 5.1 | 23.8 | 49.3 | ... | 1.1 | 21.8 | 7.7 | 7.2 | 3.7 | 7.3 | 2.3 | 6.4 | |
| Ford | 3.2 | 31.0 | 67.4 | 12.9 | 57.7 | 60.3 | 6.9 | ... | 70.1 | 0.8 | 1.2 | ... | 22.6 | 1.4 | 2.1 | 5.8 | 2.4 | 7.9 | 287,737 |
| Econoline | 18.4 | 26.5 | 79.4 | 28.9 | 32.8 | 35.4 | 16.8 | 8.2 | 44.9 | ... | 22.6 | ... | 9.6 | ... | 0.4 | 4.2 | ... | 32.4 | 107,735 |
| Bronco | 82.0 | 43.5 | 76.7 | 29.5 | 28.2 | 22.0 | 29.4 | ... | 43.9 | ... | 42.6 | ... | 27.7 | ... | 0.6 | ... | ... | 33.7 | 59,468 |
| Van | 9.6 | 14.7 | 67.6 | 21.1 | 13.9 | 18.8 | 6.4 | ... | 45.4 | 9.2 | 2.7 | ... | ... | ... | ... | ... | ... | 5.2 | 21,857 |
| Pinto | 1.8 | 45.0 | 90.8 | 13.5 | 74.3 | 78.2 | 7.4 | 13.8 | 78.1 | ... | 1.8 | ... | 37.1 | 4.1 | 7.1 | 9.1 | 6.4 | 6.4 | 91,224 |
| Capri | 12.7 | 25.4 | 83.3 | 22.9 | 42.3 | 47.0 | 10.6 | 10.4 | 80.1 | ... | 12.0 | ... | 0.8 | ... | 0.9 | 5.9 | ... | 16.8 | 121,516 |
| Granada | 28.5 | 85.1 | 99.6 | 21.6 | 95.6 | 96.9 | 18.8 | ... | 64.0 | ... | 33.0 | 59.3 | 11.2 | ... | 2.6 | ... | ... | 37.8 | 49,768 |
| Continental | 2.3 | 62.4 | 81.7 | 22.8 | 20.2 | 28.7 | 4.8 | ... | 77.7 | ... | 3.6 | ... | ... | ... | ... | ... | ... | 6.1 | 45,751 |
| Continental Mark III | 94.3 | 63.2 | 92.8 | 28.5 | 35.8 | 34.9 | 22.4 | ... | 52.7 | ... | 36.2 | 24.0 | 10.3 | ... | 1.2 | ... | ... | 39.5 | 85,032 |
| Thunderbird | 9.2 | 57.7 | 93.9 | 10.6 | 82.5 | 84.9 | 9.4 | 91.3 | 8.7 | ... | 2.0 | 20.0 | 22.0 | 10.4 | 15.0 | 7.3 | 18.2 | 53.7 | 103,777 |
| Mercury | 9.5 | 99.5 | 98.7 | ... | 99.3 | 99.3 | 23.4 | 100.0 | ... | ... | ... | 100.0 | ... | 69.1 | 66.6 | ... | 80.4 | ... | 11,915 |
| Chrysler Units | 257,753 | 509,970 | 1,042,187 | 263,609 | 604,006 | 665,000 | 150,709 | 215,305 | 662,721 | 24,355 | 145,814 | 97,411 | 189,389 | 34,304 | 51,420 | 53,635 | 54,705 | 265,695 | 1,511,073 |
| % Tot. Output | 19.7 | 38.9 | 79.5 | 20.1 | 46.1 | 50.8 | 11.5 | 16.4 | 50.5 | 1.9 | 11.1 | 7.4 | 14.4 | 2.6 | 3.9 | 4.1 | 4.2 | 20.3 | |
| AMC | 100.0 | ... | ... | 21.6 | 41.2 | 25.7 | 82.6 | ... | ... | 100.0 | ... | ... | 50.1 | 22.0 | ... | ... | ... | 100.0 | 4,316 |
| Rebel | 6.9 | 11.8 | 49.4 | 13.1 | 22.4 | 18.0 | 16.2 | 55.7 | 40.4 | 3.9 | ... | ... | 21.8 | 2.3 | 0.5 | 13.8 | 32.3 | 4.7 | 49,725 |
| Hornet | ... | 7.1 | 40.9 | 10.4 | 19.2 | 13.6 | 2.4 | 51.6 | 48.4 | ... | ... | ... | 7.8 | ... | ... | ... | 27.7 | ... | 73,543 |
| Ambassador | 6.5 | 22.6 | 82.0 | 24.7 | 59.7 | 89.3 | 12.6 | 59.0 | 5.0 | ... | ... | 56.1 | 9.5 | 13.2 | 7.2 | 23.3 | 63.8 | 7.3 | 59,941 |
| Javelin | 100.0 | 38.4 | 97.9 | 23.9 | 19.7 | 24.9 | 9.9 | 69.2 | 13.4 | ... | 17.3 | ... | 22.4 | 6.2 | ... | ... | 1.0 | 21.5 | 32,634 |
| Gremlin | 25.0 | ... | 60.9 | 6.7 | 14.2 | 9.5 | 3.4 | 51.9 | 48.1 | ... | ... | ... | ... | ... | ... | ... | 6.3 | ... | 15,044 |
| Tot. AMC Units | 40,265 | 36,176 | 135,379 | 38,165 | 67,561 | 83,423 | 24,603 | 136,097 | 74,925 | 6,052 | 5,210 | 33,656 | 33,385 | 11,741 | 4,572 | 20,529 | 67,765 | 17,213 | 242,603 |
| % Tot. Output | 20.0 | 14.9 | 55.8 | 15.7 | 27.8 | 34.4 | 10.1 | 56.5 | 30.9 | 2.5 | 2.1 | 13.9 | 13.8 | 4.8 | 1.9 | 8.6 | 27.9 | 7.1 | |
| Total Industry Units | 1,213,053 | 3,198,765 | 6,390,412 | 922,354 | 4,552,797 | 4,620,750 | 621,674 | 1,803,313 | 3,504,006 | 50,940 | 657,795 | 1,599,741 | 1,016,874 | 719,268 | 341,119 | 369,232 | 170,854 | 925,357 | 7,886,359 |
| % Tot. Output | 15.3 | 40.6 | 81.1 | 12.0 | 59.2 | 60.1 | 8.1 | 24.5 | 46.2 | 0.6 | 8.6 | 20.8 | 13.2 | 9.4 | 4.4 | 5.1 | 2.2 | 11.9 | |

Note: All Chrysler Corp. installation rates are based on cars built both in U.S. and Canada for sale in the U.S. only. '70 model output of Corvette, Camaro and Firebird did not begin until early 1970. Maverick includes '69 and '70 models. Falcon is '70 made through Dec. 3, 1969. Mercury's 145,523 is North American production.

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# U.S. Car Factory-Installed Equipment Rates (%)—1971 Model Year

| Models | Automatic Transmission | 4-Speed Manual Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power 4-Wheel Drum Brakes | Front Wheel Disc Standard | Front Wheel Disc Optional | Power Door Locks | 2-Way Power Seats | 4- or 6-Way Power Seats | Power Windows | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 53.1 | ... | 59.6 | 38.9 | 1.5 | 84.2 | 10.5 | 5.4 | ... | 99.8 | ... | 100.0 | ... | 3.7 | ... | 3.3 | 5.4 | 6[illegible] |
| Chevelle | 46.1 | 53.9 | 66.8 | 33.2 | ... | 98.7 | 15.1 | ... | ... | 82.1 | ... | ... | 67.2 | ... | ... | ... | 22.4 | 2[illegible] |
| Chevelle | 51.7 | 3.2 | 58.3 | 44.1 | 6.6 | 83.5 | 6.4 | 4.1 | ... | 90.5 | 32.9 | ... | 22.2 | 1.2 | ... | ... | 7.5 | [illegible] |
| Chevelle | 81.7 | 2.0 | 38.7 | 12.6 | 48.7 | 83.1 | 1.9 | ... | ... | 61.6 | 10.5 | ... | 7.4 | ... | ... | ... | ... | [illegible] |
| Nova | 59.4 | 0.3 | 55.3 | 44.7 | ... | 76.7 | 21.1 | 15.0 | ... | 59.3 | ... | 100.0 | ... | 1.2 | ... | 2.4 | 8.8 | [illegible] |
| Monte Carlo | 73.4 | 9.3 | 49.0 | 41.2 | 9.8 | 83.6 | 11.6 | ... | ... | 81.3 | ... | ... | 59.3 | ... | ... | ... | ... | [illegible] |
| Camaro | 43.1 | 33.1 | ... | ... | ... | 96.0 | 3.7 | ... | ... | 9.5 | ... | 100.0 | ... | ... | ... | ... | ... | [illegible] |
| Vega | | | | | | | | | | | | | | | | | | |
| Pontiac | 55.9 | ... | 100.0 | ... | ... | 74.1 | 12.7 | 10.0 | ... | 100.0 | ... | 100.0 | ... | 8.7 | 0.2 | 12.1 | 53.1 | [illegible] |
| Grand Prix | 95.8 | 0.1 | 100.0 | ... | ... | 48.1 | 25.0 | 26.5 | ... | 100.0 | ... | 100.0 | ... | 9.4 | ... | 18.8 | 58.3 | [illegible] |
| LeMans | 93.5 | 2.1 | 6.4 | 65.7 | 7.9 | 87.6 | 5.3 | 3.2 | ... | 54.7 | 21.7 | 0.4 | 25.0 | 0.8 | ... | 0.9 | 5.3 | [illegible] |
| Firebird | 87.8 | 0.0 | 59.7 | 37.7 | 5.6 | 73.0 | 9.8 | 8.4 | ... | 90.0 | ... | 4.0 | 54.9 | 1.2 | ... | ... | 4.5 | [illegible] |
| Ventura II | 87.4 | ... | ... | 40.8 | 53.2 | 92.0 | 0.9 | ... | ... | 61.7 | 9.5 | ... | 3.1 | ... | ... | ... | ... | [illegible] |
| Oldsmobile | 100.0 | ... | 100.0 | ... | ... | 73.1 | ... | 24.2 | ... | 100.0 | ... | 100.0 | ... | 13.7 | 5.2 | 31.3 | 42.4 | [illegible] |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | 33.3 | ... | 65.6 | ... | 100.0 | ... | 100.0 | 47.3 | ... | ... | 69.2 | 90.5 | [illegible] |
| Toronado | 100.0 | ... | 100.0 | ... | ... | 86.0 | ... | 7.2 | ... | 98.7 | 40.8 | 13.9 | 28.4 | 2.3 | ... | 2.6 | 10.6 | [illegible] |
| F-85 | 98.1 | 0.8 | 59.8 | ... | 1.2 | | | | | | | | | | | | | |
| Buick | 100.0 | ... | 71.6 | 16.4 | ... | 63.6 | 15.2 | 13.2 | ... | 100.0 | ... | 100.0 | ... | 21.0 | 0.2 | 25.6 | 51.5 | [illegible] |
| Riviera | 100.0 | ... | 100.0 | ... | ... | 30.7 | 16.8 | 52.1 | ... | 100.0 | ... | 100.0 | ... | 29.4 | ... | 73.1 | 94.8 | [illegible] |
| Skylark | 59.0 | 0.4 | 28.1 | 69.6 | 2.3 | 87.1 | 9.2 | ... | ... | 97.7 | 43.8 | 0.9 | 10.5 | 1.7 | ... | 1.5 | 15.4 | [illegible] |
| Century | 100.0 | ... | 100.0 | ... | ... | ... | 29.1 | 70.2 | ... | 100.0 | ... | 100.0 | ... | 29.9 | 2.7 | 99.4 | ... | [illegible] |
| Gran Sport | 100.0 | ... | 100.0 | ... | ... | ... | 11.1 | 88.8 | ... | 100.0 | ... | 100.0 | ... | 57.9 | 2.4 | 97.5 | ... | [illegible] |
| Electra | 100.0 | ... | 100.0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | [illegible] |
| Total GM Units | 3,290,699 | 136,053 | 2,148,537 | 959,005 | 186,217 | 2,687,081 | 360,704 | 446,453 | — | 3,121,737 | 357,252 | 2,511,797 | 312,003 | 355,616 | 25,432 | 513,079 | 822,787 | 3,516,283 |
| % Total Output | 92.5 | 3.8 | 60.4 | 27.0 | 5.2 | 75.6 | 10.1 | 12.6 | — | 87.8 | 10.0 | 70.6 | 8.8 | 10.0 | 0.7 | 14.4 | 23.1 | — |
| Falcon | 99.5 | ... | 63.8 | 35.7 | 0.5 | 82.5 | 9.0 | 2.2 | ... | 90.0 | 1.8 | 36.8 | 26.4 | 3.0 | ... | 4.6 | 10.9 | 2.4 [illegible] |
| Torino | 95.0 | 1.1 | 10.9 | 59.2 | 8.9 | 83.9 | 2.9 | ... | ... | 90.4 | ... | 5.6 | 27.5 | ... | ... | 0.5 | 15.2 | [illegible] |
| Maverick | 76.3 | ... | ... | 12.0 | 86.0 | 87.5 | ... | ... | ... | 28.2 | ... | ... | ... | ... | ... | ... | ... | [illegible] |
| Montego | 83.9 | 5.3 | 25.4 | 64.8 | 9.8 | 83.7 | 0.1 | 5.6 | ... | 85.7 | ... | 1.0 | 33.9 | ... | ... | ... | 1.9 | [illegible] |
| Thunderbird | 100.0 | ... | 100.0 | ... | ... | 26.0 | 50.6 | 13.5 | 36.0 | 100.0 | ... | 100.0 | ... | 46.3 | ... | 71.0 | 89.5 | [illegible] |
| Pinto | 47.1 | 52.9 | ... | ... | ... | 80.4 | ... | ... | ... | ... | ... | ... | 35.0 | ... | ... | ... | ... | [illegible] |
| Mercury | 100.0 | ... | 59.6 | 40.4 | ... | 62.2 | 28.3 | 7.7 | 14.8 | 100.0 | ... | 100.0 | ... | 16.8 | ... | 30.3 | 47.5 | [illegible] |
| Marquis | 97.1 | 0.8 | 2.3 | 89.2 | 8.5 | 52.6 | 3.9 | ... | ... | 94.5 | ... | ... | 43.5 | ... | ... | 0.8 | 8.9 | [illegible] |
| Cougar | 96.9 | 1.0 | 87.9 | 12.1 | ... | 68.7 | 20.8 | 9.0 | ... | 96.5 | ... | ... | 73.7 | ... | ... | 4.5 | 5.9 | [illegible] |
| Comet | 81.0 | ... | ... | 38.1 | 61.9 | 87.0 | ... | ... | ... | 48.3 | ... | ... | ... | ... | ... | ... | ... | [illegible] |
| Lincoln | 100.0 | ... | 100.0 | ... | ... | 17.1 | 66.7 | 15.9 | 93.7 | 100.0 | ... | 100.0 | ... | 59.4 | 2.8 | 90.2 | 100.0 | [illegible] |
| Mark III | 100.0 | ... | 100.0 | ... | ... | 4.2 | 74.7 | 21.0 | 99.0 | 100.0 | ... | 100.0 | ... | 50.7 | 3.1 | 96.9 | 100.0 | [illegible] |
| Total Ford Units | 1,887,270 | 147,713 | 791,979 | 791,242 | 231,600 | 1,689,007 | 375,359 | 58,025 | 77,503 | 1,506,432 | 14,054 | 640,819 | 472,233 | 120,525 | 2,161 | 173,720 | 455,466 | 2,241,227 |
| % Total Output | 69.0 | 7.0 | 37.3 | 37.3 | 10.9 | 79.6 | 17.7 | 2.7 | 3.7 | 75.3 | 0.7 | 23.9 | 22.0 | 5.7 | 0.1 | 8.2 | 21.5 | — |
| Fury | 99.5 | ... | 33.0 | 65.8 | 1.2 | 82.0 | ... | 3.9 | ... | 97.1 | ... | 0.1 | 77.3 | 1.5 | ... | 1.9 | 4.1 | [illegible] |
| Satellite | 93.1 | 2.6 | 82.5 | 9.6 | 7.9 | 86.0 | ... | 4.6 | ... | 50.1 | 12.0 | ... | 22.1 | ... | ... | ... | 8.9 | [illegible] |
| Barracuda | 78.7 | 12.3 | 62.3 | 27.7 | 10.0 | 81.7 | ... | 15.3 | ... | 71.3 | 6.0 | ... | 24.7 | ... | ... | ... | 2.6 | [illegible] |
| Valiant | 82.6 | 1.1 | 24.9 | ... | 74.1 | 86.4 | ... | 0.4 | ... | 57.3 | 1.6 | ... | 2.4 | ... | ... | ... | ... | [illegible] |
| Polara | 99.8 | ... | 99.9 | 63.0 | 0.1 | 80.2 | ... | 5.8 | ... | 90.9 | ... | 7.2 | 78.4 | 3.5 | ... | 5.2 | 13.9 | [illegible] |
| Coronet/Charger | 99.6 | 1.1 | 77.5 | 17.2 | 5.3 | 88.5 | ... | 5.8 | ... | 99.5 | 12.7 | ... | 23.4 | ... | ... | ... | 12.7 | [illegible] |
| Challenger | 88.7 | 5.3 | 76.5 | 15.8 | 6.7 | 81.0 | ... | 11.7 | ... | 60.2 | 5.3 | ... | 15.1 | ... | ... | ... | 2.7 | [illegible] |
| Dart | 91.1 | 1.0 | 31.3 | ... | 68.7 | 90.0 | ... | 0.2 | ... | 73.0 | 1.7 | ... | 2.4 | ... | ... | ... | ... | [illegible] |
| Chrysler | 99.9 | ... | 88.8 | 11.2 | ... | 71.6 | 8.8 | 17.9 | 8.1 | 99.9 | ... | 62.2 | 30.8 | 15.1 | ... | 23.5 | 32.6 | [illegible] |
| Imperial | 100.0 | ... | 100.0 | ... | ... | ... | 19.6 | 80.1 | ... | 100.0 | ... | 100.0 | ... | 81.5 | ... | 97.3 | 100.0 | [illegible] |
| Total Chrysler Units | 1,180,292 | 12,293 | 646,076 | 318,474 | 289,625 | 1,062,794 | 17,507 | 80,510 | 14,118 | 1,079,831 | 26,936 | 123,235 | 438,672 | 39,726 | — | 72,243 | 181,184 | 2,[illegible] |
| % Total Output | 84.0 | 1.0 | 51.4 | 25.4 | 23.1 | 84.6 | 1.4 | 6.4 | 1.1 | 86.0 | 2.9 | 10.2 | 34.9 | 3.1 | — | 5.8 | 10.2 | — |
| Maverick | 93.5 | 0.1 | ... | 61.9 | 30.5 | 67.5 | 1.0 | 0.1 | ... | 50.0 | 10.1 | ... | 9.4 | ... | ... | ... | 11.5 | [illegible] |
| Hornet | 99.2 | 0.5 | 1.0 | 5.2 | 70.5 | 42.3 | ... | ... | ... | 26.6 | 4.9 | ... | 1.2 | ... | ... | ... | ... | [illegible] |
| Ambassador | 100.0 | ... | 81.0 | 14.6 | 1.4 | 75.5 | 5.6 | 1.0 | ... | 59.0 | 58.7 | ... | 29.7 | ... | ... | ... | 22.9 | 4[illegible] |
| Javelin/AMX | 93.4 | 3.9 | 7.1 | 74.5 | 10.1 | 74.2 | 4.9 | 3.2 | ... | 70.5 | 10.7 | ... | 47.9 | ... | ... | ... | ... | [illegible] |
| Gremlin | 47.0 | ... | ... | ... | 100.0 | 55.2 | ... | ... | ... | 11.7 | 1.3 | ... | ... | ... | ... | ... | ... | [illegible] |
| Total AMC Units | 124,929 | 1,559 | 37,537 | 61,206 | 124,751 | 142,078 | 4,206 | 1,470 | — | 120,013 | 35,642 | — | 22,019 | — | — | — | 28,[illegible] | [illegible] |
| % Total Output | 91.1 | 0.6 | 15.5 | 25.1 | 51.0 | 58.4 | 1.8 | 0.6 | — | 61.9 | 19.2 | — | 11.5 | — | — | — | 9.[illegible] | — |
| TOTAL INDUSTRY UNITS | 6,542,600 | 297,618 | 3,624,429 | 2,130,617 | 830,573 | 5,672,100 | 758,010 | 586,458 | 77,503 | 5,924,013 | 440,884 | 3,288,071 | 1,297,727 | 522,633 | 27,593 | 759,422 | 1,487,[illegible] | 17,[illegible] |
| % TOTAL OUTPUT | 91.1 | 4.1 | 50.5 | 29.7 | 11.6 | 77.6 | 10.6 | 8.2 | 1.1 | 82.5 | 6.2 | 45.8 | 17.5 | 7.3 | 0.4 | 10.6 | 21.7 | — |

Note: All Chrysler Corp. installation rates are based on cars built in U.S. and Canada for sale in U.S. Ford Division rates exclude cars built in U.S. for sale in Canada. Mercury installation rates are based on combined U.S. and Canada output. The Stereo Tape item includes Stereo Radio and Stereo Radio-Tape, but varies by car lines. *Includes 21,056 Ford Club Wagons for which installation rates are not figured.

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# U.S. Car Factory-Installed Equipment Rates (%)—1971 Model Year (continued)

| Models | Bucket Seats | Vinyl Roof | Whitewall Tires | Tinted Windshield | Tinted Windshield & Windows | Air Conditioner Automatic Temp. Control | Air Conditioner Manual Temp. Control | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Electric Clock | Movable Steering Column | Speed Regulating Device | Reclining Front Seat | Dual Exhausts | % Total Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 10.0 | 41.8 | 82.3 | 4.5 | 80.4 | 2.3 | 79.9 | 3.9 | 12.7 | 62.5 | 13.9 | --- | 25.3 | 12.2 | 3.5 | --- | 20.1 | 24.9 |
| Corvette | 100.0 | 3.8 | 87.9 | --- | 100.0 | --- | 52.7 | 100.0 | --- | 13.8 | * | 24.0 | 100.0 | 37.3 | --- | --- | 42.1 | 3.1 |
| Chevelle | 10.3 | 35.5 | 81.8 | 1.4 | 77.9 | --- | 55.3 | --- | --- | 55.0 | --- | 14.0 | 11.1 | 4.1 | 1.9 | --- | 4.2 | 10.5 |
| Camaro | 3.3 | 15.4 | 69.2 | --- | 38.7 | --- | 19.7 | 3.7 | --- | 33.5 | --- | 30.0 | 3.0 | --- | --- | --- | 3.6 | 5.2 |
| Nova | 10.3 | 79.0 | 95.8 | 1.4 | 73.9 | --- | 87.4 | 6.5 | --- | 22.5 | --- | 37.0 | 100.0 | 21.2 | 1.9 | --- | 9.2 | 15.2 |
| Monte Carlo | 100.0 | 33.4 | 98.2 | 0.7 | 58.7 | --- | 27.1 | 10.3 | --- | 42.9 | --- | 24.4 | 9.3 | 2.3 | --- | --- | 12.3 | 3.1 |
| Camaro | 100.0 | --- | 60.3 | --- | 31.4 | --- | 16.4 | 3.9 | --- | --- | --- | --- | 4.2 | --- | --- | --- | --- | 1.1 |
| Vette | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pontiac | --- | 56.2 | 94.2 | 20.3 | 72.2 | 4.7 | 80.2 | 6.0 | 45.0 | 50.1 | --- | 5.6 | 51.0 | 17.0 | 8.2 | --- | 5.3 | 2.1 |
| Grand Prix | 91.7 | 87.7 | 99.5 | 17.5 | 86.4 | 6.1 | 83.4 | 7.5 | 30.9 | --- | --- | 69.1 | 100.0 | 34.0 | 10.9 | --- | --- | 1.4 |
| LeMans | 28.4 | 33.7 | 83.8 | 27.8 | 42.5 | --- | 60.7 | 5.3 | --- | 61.4 | --- | 23.0 | 15.9 | 2.1 | 0.7 | --- | 12.7 | 1.4 |
| Firebird | 100.0 | 31.5 | 69.1 | 30.1 | 45.6 | --- | 57.4 | 10.9 | 17.4 | 20.1 | 4.0 | 45.7 | 11.6 | 5.7 | --- | --- | --- | 1.4 |
| Ventura II | 4.9 | 2.9 | 84.5 | --- | 9.3 | --- | 22.3 | 0.9 | --- | 63.3 | --- | 5.2 | 2.1 | --- | --- | --- | --- | 1.1 |
| Catalina | --- | 72.9 | 95.3 | 15.6 | 79.5 | 8.2 | 81.3 | 6.6 | 81.7 | 16.7 | --- | 1.5 | 59.0 | 32.8 | 12.5 | --- | 2.1 | 3.1 |
| Bonneville | --- | 93.5 | 95.3 | 5.9 | --- | 29.2 | 69.3 | --- | 100.0 | --- | --- | --- | 100.0 | 76.5 | 25.9 | --- | --- | 1.1 |
| Tempest | 13.2 | 59.0 | 89.9 | 27.3 | 57.5 | --- | 73.0 | 5.5 | 2.1 | 71.4 | --- | 19.3 | 17.5 | 5.5 | 1.7 | --- | 4.7 | 1.1 |
| Ventura | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Grand Safari | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Grand Ville | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total GM Units | 571,134 | 1,672,752 | 2,974,006 | 393,403 | 2,275,977 | 272,756 | 2,136,591 | 213,007 | 850,913 | 1,425,509 | 23,622 | 364,775 | 1,320,102 | 604,722 | 235,703 | — | 277,408 | 3,550,013 |
| % Total Output | 16.1 | 47.0 | 83.6 | 11.1 | 64.0 | 7.7 | 60.1 | 6.0 | 23.9 | 40.1 | 0.7 | 10.3 | 37.4 | 17.0 | 6.7 | — | 7.8 | — |
| Ford | 0.5 | 47.3 | --- | 6.2 | 75.0 | 2.3 | 50.1 | 3.3 | 24.7 | 55.4 | --- | 4.3 | 55.9 | 4.5 | 3.4 | 2.3 | 2.1 | 3,550,013 |
| Falcon | 3.6 | 29.6 | 82.4 | 2.6 | 66.3 | --- | 50.8 | 6.4 | 2.9 | 23.3 | --- | 1.1 | 5.8 | --- | --- | --- | 5.4 | --- |
| Torino | 7.4 | 10.11 | 78.2 | --- | 34.7 | --- | 22.1 | --- | --- | 65.3 | --- | --- | 0.4 | --- | --- | --- | --- | --- |
| Maverick | 100.0 | 22.0 | 87.4 | 1.9 | 45.8 | --- | 40.5 | 3.9 | 26.7 | 57.4 | --- | 2.7 | 25.9 | 3.2 | --- | --- | 18.5 | --- |
| Mustang | 23.6 | 64.0 | 95.5 | --- | 97.0 | 24.2 | 73.9 | 6.7 | 87.8 | 12.2 | --- | --- | 100.0 | 65.7 | 27.1 | 16.2 | 100.0 | 5 |
| Thunderbird | 100.0 | 5.4 | 61.6 | --- | 22.5 | --- | 10.7 | --- | --- | 74.2 | --- | --- | 7.0 | --- | --- | --- | --- | --- |
| Pinto | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Mercury | --- | 70.8 | 95.0 | 1.0 | 89.4 | 22.4 | 67.6 | 7.3 | 71.0 | 19.1 | --- | --- | 100.0 | 29.5 | 16.1 | 6.6 | --- | --- |
| Capri | 5.6 | 46.9 | 81.9 | 3.6 | 56.2 | --- | 58.3 | 2.0 | 17.4 | 67.4 | --- | --- | 3.4 | --- | --- | --- | 4.7 | --- |
| Montego | 100.0 | 75.0 | 96.2 | 3.5 | 74.3 | --- | 75.0 | 2.6 | 47.0 | 45.0 | --- | 3.5 | 55.5 | 17.0 | --- | --- | 12.1 | --- |
| Cougar | 15.9 | 17.0 | 67.4 | 4.2 | 25.0 | --- | 24.6 | --- | --- | 61.8 | --- | --- | --- | --- | --- | --- | --- | --- |
| Comet | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Lincoln | --- | 91.5 | 99.7 | --- | 100.0 | 97.3 | 2.7 | 12.3 | 53.1 | 16.9 | --- | --- | 100.0 | 72.1 | 42.0 | 23.1 | 100.0 | --- |
| Valiant | --- | 33.8 | 93.8 | --- | 100.0 | 100.0 | --- | 15.6 | 100.0 | --- | --- | --- | 100.0 | 88.0 | 61.7 | 25.3 | --- | --- |
| Total Ford Units | 523,260 | 781,355 | 1,722,509 | 70,893 | 1,258,033 | 117,825 | 1,160,319 | 80,907 | 437,472 | 1,098,355 | — | 60,019 | 747,630 | 162,511 | 93,023 | 48,624 | 225,865 | 2,190,027 |
| % Total Output | 25.7 | 35.8 | 81.2 | 3.3 | 59.3 | 5.6 | 55.7 | 3.8 | 23.0 | 50.4 | — | 2.8 | 35.3 | 7.7 | 4.4 | 2.3 | 6.1 | — |
| Dart | 1.9 | 40.0 | 80.2 | 9.2 | 76.8 | --- | 82.9 | 5.7 | --- | 50.7 | 0.1 | 0.6 | 69.2 | 1.2 | 2.5 | 2.3 | 5.5 | --- |
| Valiant | 11.1 | 32.0 | 70.3 | 20.8 | 47.9 | --- | 55.4 | 5.3 | 12.6 | 55.0 | --- | 11.2 | 12.1 | 0.4 | 0.3 | --- | 12.1 | --- |
| Barracuda | 67.0 | 45.6 | 81.2 | 27.7 | 32.4 | --- | 20.6 | 22.1 | --- | 44.9 | --- | 41.3 | 22.3 | --- | --- | --- | 6.2 | --- |
| Challenger | 5.6 | 29.0 | 74.0 | 18.1 | 20.4 | --- | 26.6 | 3.5 | --- | 61.6 | --- | 5.0 | --- | --- | --- | --- | 4.9 | --- |
| Valiant | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Polara | 0.9 | 60.8 | 87.8 | 6.4 | 83.2 | --- | 62.9 | 6.5 | 7.2 | 81.1 | --- | 1.3 | 74.2 | 3.7 | 15.5 | 5.0 | 8.5 | --- |
| Coronet | 18.5 | 38.8 | 83.5 | 15.3 | 57.4 | --- | 63.6 | 7.0 | 15.5 | 56.0 | --- | 11.0 | 22.5 | 0.8 | 1.9 | --- | 12.3 | --- |
| Coronet/Charger | 92.6 | 64.5 | 92.6 | 21.3 | 43.5 | --- | 49.2 | 11.6 | --- | 50.5 | --- | 22.1 | 20.3 | --- | --- | --- | 21.6 | --- |
| Charger | 4.9 | 41.8 | 80.3 | 21.1 | 24.0 | --- | 38.2 | 3.6 | --- | 71.0 | --- | 4.3 | --- | --- | --- | --- | 3.9 | --- |
| Dart | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chrysler | 7.0 | 62.5 | 94.8 | 8.0 | 55.2 | 8.4 | 81.3 | 5.2 | 92.8 | 100.0 | 5.3 | --- | 1.9 | 49.9 | 11.1 | 12.9 | 17.5 | 34.9 |
| Imperial | --- | 100.0 | 99.7 | --- | 99.7 | 81.2 | 19.2 | 22.0 | 100.0 | --- | --- | --- | --- | 97.5 | 76.5 | 74.2 | 55.7 | --- |
| Total Chrysler Units | 123,159 | 573,412 | 1,031,037 | 173,313 | 722,121 | 23,523 | 758,700 | 81,107 | 221,563 | 747,900 | 273 | 70,203 | 400,119 | 37,022 | 68,400 | 82,305 | 144,503 | 1,241,119 |
| % Total Output | 5.3 | 45.7 | 82.1 | 13.3 | 57.5 | 1.9 | 60.4 | 6.5 | 17.6 | 59.5 | — | 5.6 | 32.0 | 3.0 | 5.4 | 6.6 | 11.5 | — |
| Valiant | 5.2 | 19.0 | 61.0 | 14.1 | 30.0 | --- | 31.4 | 7.2 | --- | 53.5 | 1.0 | 0.3 | 17.7 | 1.9 | 0.9 | --- | 0.7 | --- |
| Duster | --- | 7.2 | 37.2 | 7.1 | 17.4 | --- | 14.4 | 3.0 | --- | 31.2 | --- | 0.2 | 11.3 | --- | --- | --- | 0.7 | --- |
| Demon | 3.7 | 33.6 | 73.0 | 18.1 | 15.8 | --- | 30.0 | 11.3 | 87.4 | 4.1 | 7.1 | 0.9 | 23.1 | 14.0 | 2.2 | 9.6 | 9.2 | --- |
| Scamp | 100.0 | 43.7 | 63.1 | 23.9 | 20.8 | --- | 37.7 | 11.2 | 91.4 | 12.9 | --- | 10.5 | 11.2 | 0.4 | --- | --- | 11.1 | --- |
| Gran Fury | 3.0 | --- | 58.3 | 8.4 | 15.3 | --- | 15.3 | 2.2 | --- | 79.5 | --- | 15.2 | 32.0 | --- | --- | --- | --- | --- |
| Total AMC Units | 52,360 | 37,027 | 124,692 | 30,208 | 70,106 | — | 82,303 | 14,705 | 51,307 | 60,524 | 2,054 | 13,012 | 31,772 | 8,243 | 3,725 | 55,353 | 6,650 | 244,114 |
| % Total Output | 21.4 | 15.2 | 51.0 | 12.8 | 29.7 | — | 33.5 | 6.0 | 21.0 | 24.7 | 0.8 | 5.7 | 13.0 | 3.5 | 1.5 | 23.0 | 2.7 | — |
| TOTAL INDUSTRY UNITS | 1,250,753 | 3,064,626 | 5,843,144 | 669,042 | 4,320,347 | 414,004 | 4,330,023 | 350,720 | 1,611,316 | 3,330,088 | 25,249 | 509,046 | 2,403,273 | 813,393 | 401,852 | 187,422 | 653,426 | 7,000,000 |
| % TOTAL OUTPUT | 12.7 | 42.7 | 81.4 | 9.3 | 60.3 | 5.8 | 57.6 | 5.4 | 22.5 | 46.1 | 0.4 | 7.1 | 33.6 | 11.3 | 5.6 | 2.2 | 7.9 | — |

Note: All Chrysler Corp. installation rates are based on cars built in U.S. and Canada for sale in U.S. Ford Division rates exclude cars built in U.S. for sale in Canada. Mercury installation rates are based on combined U.S. and Canada output. The Stereo Tape item includes Stereo Radio and Stereo Radio-Tape, but varies by car lines. *Includes 21,656 Ford Club Wagons for which installation rates are not figured.

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E-1356

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '72 MODEL CARS

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4-Wheel Disc | Disc Brakes Manual Standard | Disc Brakes Manual Optional | Power Door Locks | Power Seats 2-Way Only | 4-or 6-Way Power Seats | Total Power Windows | Bucket Seats | Autos Equipped as Total Output of* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 99.8 | ... | 57.8 | 41.8 | 0.4 | 77.3 | 13.1 | 3.4 | 2.8 | 100.0 | ... | 100.0 | | | 6.3 | ... | 4.3 | 16.4 | ... | 926,541 |
| Corvette | 50.9 | 46.1 | 79.0 | 21.0 | | | 72.2 | 26.6 | | 68.1 | ... | 69.5 | 30.5 | | ... | ... | ... | 35.2 | 100.0 | 21,024 |
| Chevelle | 94.8 | 2.5 | 36.5 | 55.3 | 5.2 | 85.3 | 7.3 | 0.9 | 4.3 | 92.9 | 42.4 | 30.2 | ... | | 1.7 | ... | ... | 2.9 | 9.8 | 357,319 |
| Nova | 85.3 | 1.7 | 37.0 | 23.0 | 40.0 | 65.3 | 3.1 | | | 71.1 | 16.6 | 10.2 | ... | | ... | ... | ... | | 5.5 | 267,997 |
| Monte Carlo | 98.5 | | 51.8 | 43.2 | | 69.2 | 21.1 | 6.3 | 14.1 | 100.0 | ... | 100.0 | ... | | 1.7 | ... | 2.9 | 9.9 | 9.9 | 162,105 |
| Camaro | 52.7 | 8.5 | 40.3 | 52.7 | 7.0 | 79.1 | 15.2 | | | 87.2 | ... | 47.6 | 57.4 | | ... | ... | ... | | 100.0 | 65,931 |
| Vega 2300 | 40.5 | 39.9 | | | | 84.5 | 6.3 | 26.6 | | 3.1 | ... | | 100.0 | | ... | ... | ... | ... | 100.0 | 255,478 |
| Panel Exp. | 100.0 | ... | 100.0 | ... | ... | 60.1 | 16.6 | 8.6 | 4.8 | 100.0 | ... | -100.0 | ... | | ... | ... | ... | ... | 100.0 | 274,021 |
| Chevy Van | 100.0 | ... | 100.0 | ... | ... | 33.5 | 28.8 | 31.0 | 8.4 | 100.0 | ... | 100.0 | ... | | 10.3 | 0.2 | 11.8 | 25.4 | 9.2 | 91,555 |
| Vettes | 94.0 | 1.6 | 37.2 | 69.4 | 3.4 | 78.8 | 11.0 | 3.0 | 2.7 | 95.4 | 20.0 | 49.0 | ... | | 12.9 | ... | 12.9 | 61.5 | 90.2 | 91,555 |
| Firebird | 89.3 | 9.0 | 57.9 | 34.4 | 3.7 | 71.6 | 15.1 | 8.0 | 7.5 | 96.0 | | 65.2 | 34.8 | | 1.5 | ... | 1.3 | 10.6 | 25.6 | 161,593 |
| Vettes II | 61.2 | | | 62.2 | 37.8 | 89.2 | 1.9 | | | 77.4 | 21.0 | 8.3 | ... | | 2.4 | ... | ... | 7.6 | 100.0 | 65,931 |
| Oldsmobile | 100.0 | ... | 100.0 | ... | ... | 50.1 | 10.3 | 26.3 | 7.4 | 100.0 | ... | 100.0 | ... | | 23.3 | 1.9 | 35.8 | 42.4 | ... | 274,021 |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | 19.6 | 4.9 | 72.1 | 22.9 | 100.0 | ... | 100.0 | ... | | 70.0 | ... | 91.5 | 96.7 | ... | 45,610 |
| Delta | 97.7 | 0.8 | 100.0 | ... | ... | 75.2 | 11.7 | 6.2 | 3.8 | 94.3 | 42.9 | 43.3 | 0.1 | | 2.7 | ... | 2.3 | 17.6 | 22.9 | 91,555 |
| Omega | 100.0 | ... | 75.4 | 24.6 | ... | 49.4 | 17.0 | 20.3 | 10.2 | 100.0 | ... | 100.0 | ... | | 26.3 | 0.3 | 42.9 | 65.0 | ... | 411,047 |
| Starfire | 97.2 | 0.3 | 70.3 | 18.7 | ... | 14.1 | 12.7 | 45.3 | 27.0 | 100.0 | ... | 100.0 | ... | | 42.4 | ... | 85.4 | 96.0 | 25.7 | 137,933 |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | 82.1 | 11.9 | 1.2 | 1.6 | 98.3 | 45.6 | 22.5 | ... | | 2.1 | ... | 2.5 | 11.5 | 6.3 | 228,749 |
| Toronado | 100.0 | ... | 100.0 | ... | ... | ... | 25.1 | 74.7 | | 100.0 | ... | 100.0 | ... | | 80.6 | 3.2 | 95.0 | 100.0 | ... | 22,831 |
| Tot. GM Units | 4,182,334 | 196,839 | 2,909,149 | 1,111,664 | 508,769 | 3,168,261 | 8.3 | 9.5 | | 100.0 | ... | 100.0 | ... | | 93.4 | 1.6 | 92.4 | 100.0 | ... | 45,974 |
| % Tot. Output | 92.4 | 4.3 | 69.7 | 24.0 | 4.5 | 69.5 | 597,623 | 599,203 | 207,113 | 4,142,155 | 508,213 | 3,156,550 | 448,978 | 0 | 421,659 | 16,969 | 718,621 | 1,442,443 | 858,225 | 4,626,243 |
| | | | | | | | 12.9 | 13.0 | 4.5 | 89.5 | 11.0 | 68.2 | 9.7 | 0.0 | 13.4 | 0.4 | 15.5 | 31.3 | 12.1 | ... |
| Ford | 100.0 | ... | 67.6 | 32.2 | 0.2 | 77.7 | ... | 13.2 | 2.4 | 100.0 | 0.2 | 92.3 | | | 7.9 | ... | 6.1 | 33.7 | | 771,853 |
| Torino | 97.7 | 0.5 | 36.2 | 73.2 | 3.6 | 85.5 | ... | 7.1 | ... | 95.9 | ... | 62.1 | 37.9 | | 0.6 | ... | 1.1 | 15.0 | 5.4 | 461,762 |
| Maverick | 83.5 | | | 24.6 | 75.4 | 86.5 | ... | | ... | 50.7 | ... | | | | ... | ... | | | 12.3 | 228,753 |
| Montego | 92.4 | 2.7 | 21.9 | 20.4 | 7.7 | 82.1 | 7.4 | ... | 6.1 | 93.2 | ... | 54.9 | ... | | 48.8 | ... | 77.1 | 2.0 | 100.0 | 111,016 |
| Thunderbird | 100.0 | | 79.6 | 20.4 | | 17.5 | 69.2 | ... | 13.3 | 100.0 | ... | 100.0 | ... | | | ... | | 91.9 | 13.9 | 84,855 |
| Pinto | 52.3 | 47.7 | | | ... | 82.4 | 1.6 | ... | | | ... | | 87.5 | 0.5 | | | | | 100.0 | 407,355 |
| Mercury | 100.0 | | 75.7 | 24.3 | ... | 50.7 | 37.7 | ... | 9.6 | 100.0 | ... | 100.0 | | | 24.7 | ... | 43.5 | 44.9 | — | 174,164 |
| Montego | 97.2 | 0.2 | 0.4 | 96.8 | 2.8 | 71.0 | ... | 16.2 | | 97.8 | ... | 78.9 | 21.1 | | 1.3 | ... | 4.9 | 12.6 | 2.4 | 106,517 |
| Cougar | 96.5 | 0.5 | 100.0 | | | 56.8 | ... | 29.6 | 13.7 | 99.1 | ... | 87.9 | ... | | ... | ... | 5.7 | 10.6 | 100.0 | 53,752 |
| Comet | 43.0 | ... | | 38.3 | 61.7 | 89.0 | ... | | | 64.8 | ... | | ... | | ... | ... | | | 15.7 | 99,259 |
| Capri II | 100.0 | ... | 100.0 | ... | ... | 9.8 | ... | 74.0 | 16.2 | 100.0 | ... | 100.0 | ... | | 90.9 | 3.5 | 95.5 | 100.0 | ... | 49,519 |
| Marquis | 100.0 | ... | 100.0 | ... | ... | 3.0 | ... | 76.4 | 20.6 | 100.0 | ... | 100.0 | ... | | 93.7 | ... | 100.0 | 100.0 | ... | 41,761 |
| Tot. Ford Units | 2,359,031 | 222,526 | 1,805,626 | 909,660 | 259,617 | 1,978,002 | 115,007 | 250,024 | 73,957 | 1,996,613 | 1,781 | 1,539,375 | 603,490 | 2,543 | 222,503 | 1,609 | 272,459 | 614,145 | 760,627 | 2,633,065 |
| % Tot. Output | 89.3 | 8.5 | 68.2 | 34.5 | 9.9 | 75.1 | 4.4 | 9.5 | 2.8 | 75.8 | 0.1 | 58.5 | 22.9 | 0.1 | 8.4 | 0.1 | 10.3 | 23.3 | 28.6 | ... |
| Fury | 100.0 | ... | 28.0 | 72.0 | ... | 54.9 | 32.6 | 3.5 | 0.5 | 100.0 | ... | 70.7 | ... | ... | 2.4 | ... | 3.3 | 23.2 | 1.5 | 200,282 |
| Barracuda | 76.9 | 11.7 | 53.4 | 41.5 | 5.2 | 86.0 | ... | 4.5 | 1.0 | 94.1 | ... | 57.7 | ... | | ... | ... | ... | 12.8 | 14.8 | 81,872 |
| Valiant | 81.8 | 0.9 | 27.1 | | 5.1 | 81.3 | ... | 11.8 | 3.6 | 81.7 | ... | 34.4 | ... | | ... | ... | ... | | 100.0 | 13,403 |
| Chrysler | 100.0 | ... | 94.3 | 5.7 | 72.9 | 87.1 | 1.6 | | | 69.9 | 0.9 | 0.9 | ... | | ... | ... | ... | ... | 4.5 | 255,931 |
| Imperial | 100.0 | ... | 100.0 | ... | ... | 61.7 | 9.8 | 21.5 | 5.2 | 100.0 | ... | 100.0 | ... | | ... | ... | ... | ... | 4.5 | 255,931 |
| Polara | 100.0 | ... | 28.5 | 71.5 | ... | | 17.2 | 47.7 | 34.7 | 100.0 | ... | 100.0 | ... | | 21.5 | ... | 35.5 | 45.7 | 2.0 | 222,754 |
| Coronet/Charger | 95.2 | 0.6 | 75.4 | 19.5 | 5.1 | 45.2 | 39.2 | 6.5 | 0.8 | 100.0 | ... | 53.0 | ... | | 89.6 | ... | 93.0 | 102.0 | 11.0 | 15,716 |
| Challenger | 89.0 | 8.5 | 71.3 | 22.7 | | 66.1 | ... | 5.8 | 1.3 | 95.4 | ... | 67.3 | ... | | 6.1 | ... | 9.3 | 26.5 | 0.7 | 144,614 |
| Satellite | 93.5 | 0.7 | 35.0 | | | 63.7 | | 10.3 | 3.0 | 89.7 | ... | 35.9 | ... | | ... | ... | ... | 14.2 | 11.0 | 159,783 |
| Tot. Chrysler Units | 1,260,612 | 7,021 | 667,559 | 375,207 | 289,813 | 924,914 | 1.5 | | | 66.2 | 0.9 | 10.2 | ... | | ... | ... | ... | | 100.0 | 24,765 |
| % Tot. Output | 94.9 | 0.5 | 50.2 | 28.2 | 21.8 | 69.5 | 179,118 | 79,435 | 23,083 | 1,216,727 | 3,503 | 709,519 | 0 | 0 | 73,576 | 0 | 113,411 | 253,011 | 181,459 | 1,331,193 |
| | | | | | | | 13.5 | 6.0 | 1.7 | 91.4 | 0.6 | 53.3 | 0.0 | 0.0 | 5.5 | 0.0 | 8.5 | 21.2 | 7.6 | ... |
| Matador | 97.2 | ... | ... | 75.6 | 24.4 | 63.3 | | | | | | | | | | | | | | |
| Rebel | 83.3 | ... | ... | 10.3 | 89.7 | 50.6 | | 1.2 | ... | 87.3 | 24.2 | 21.1 | ... | 0.2 | | | | | | |
| Ambassador | 100.0 | ... | 99.9 | | 0.1 | 72.5 | 1.8 | | ... | 51.6 | 4.7 | 5.1 | ... | 4.7 | ... | ... | ... | 9.3 | 1.5 | 54,813 |
| Javelin | 89.9 | 3.7 | 11.9 | 73.5 | 9.6 | 76.5 | | 7.2 | | 99.0 | 60.3 | 39.6 | ... | | ... | ... | ... | | 0.6 | 71,055 |
| Gremlin | 55.5 | | | 13.3 | 86.2 | 58.4 | | 8.0 | 4.9 | 63.2 | 16.5 | 28.6 | ... | | ... | ... | ... | 23.8 | 0.9 | 44,034 |
| Tot. AMC Units | 214,416 | 1,004 | 47,554 | 78,574 | 132,917 | 166,819 | 1.6 | | | 71.2 | 1.2 | 1.9 | ... | 4.4 | ... | ... | ... | | 96.3 | 27,175 |
| % Tot. Output | 82.8 | 0.4 | 18.4 | 30.3 | 51.3 | 64.3 | 2,357 | 6,674 | 1,333 | 166,757 | 40,654 | 41,719 | 0 | 4.8 | | | | | 47.0 | 61,717 |
| | | | | | | | 0.9 | 2.5 | 0.5 | 51.6 | 18.9 | 16.1 | 0.0 | 7,409 | 0 | 0 | 0 | 15.0 | 57,527 | 259,125 |
| TOT. IND. UNITS | 8,016,393 | 427,400 | 4,530,029 | 2,475,105 | 891,416 | 6,223,027 | | | | | | | | 2.9 | 0.0 | 0.0 | 0.0 | 5.1 | 22.4 | |
| % Tot. Output | 90.5 | 4.8 | 51.2 | 28.0 | 10.1 | 70.5 | 894,105 | 924,791 | 285,481 | 7,522,252 | 562,352 | 5,447,543 | 1,052,468 | 9,952 | 917,551 | 18,578 | 1,104,521 | 2,356,225 | 1,413,779 | 8,849,426 |
| | | | | | | | 10.1 | 10.6 | 3.5 | 85.0 | 6.4 | 61.6 | 11.9 | 0.1 | 10.4 | 0.2 | 12.5 | 26.6 | 16.0 | |

Notes: Most all Chrysler Corp. and Ford Motor Co. installation rates are based on North American production, but the totals shown for Chrysler in the right hand column are only for U.S. production. General Motors Corp. and American Motors Corp. rates are based only on U.S. production.



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# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '72 MODEL CARS —(Continued)

| | Vinyl Roofs (Non-Convert.) | Sun Roofs | White Sidewall Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Col. | Speed Reg. Device | Reclining Front Seats | Dual Exhausts | Skid Control Device | Parts Based on Total Output of: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 39.8 | ... | 85.5 | 4.1 | 85.4 | 2.5 | 82.1 | 3.7 | 23.1 | 62.4 | ... | ... | 23.1 | 28.5 | 13.8 | 5.7 | ... | 2.8 | ... | [illegible] |
| Corvette | 3.0 | ... | 86.2 | ... | 100.0 | ... | 63.5 | 100.0 | ... | 13.3 | 100.0 | ... | 100.0 | ... | 42.1 | ... | ... | 100.0 | ... | [illegible] |
| Chevelle | 44.6 | ... | 87.5 | 1.8 | 79.7 | ... | 62.8 | 6.4 | ... | 49.8 | ... | 50.1 | ... | 11.2 | 5.0 | 1.9 | ... | 3.0 | ... | [illegible] |
| Nova | 14.8 | ... | 74.1 | 0.2 | 42.9 | ... | 26.2 | 3.3 | ... | 35.4 | ... | 25.1 | ... | 2.7 | ... | ... | ... | 3.5 | ... | [illegible] |
| Monte Carlo | 44.6 | ... | 95.3 | 1.8 | 78.7 | ... | 91.6 | 6.4 | 100.0 | ... | ... | 47.3 | 100.0 | ... | 19.5 | 1.9 | ... | 6.9 | ... | [illegible] |
| Camaro | 34.8 | ... | 93.1 | 0.8 | 64.3 | ... | 46.2 | 11.1 | ... | 41.6 | ... | 44.3 | ... | 10.8 | 5.4 | ... | ... | 13.3 | ... | [illegible] |
| Vega 2300 | ... | ... | 71.5 | 0.1 | 40.7 | ... | 21.8 | 4.4 | ... | ... | ... | 23.3 | ... | 2.3 | ... | ... | ... | ... | ... | [illegible] |
| Pontiac | 51.1 | ... | 94.7 | 15.8 | 78.4 | 4.5 | 86.0 | 5.6 | 32.7 | 43.9 | ... | 13.6 | 41.3 | 11.7 | 22.0 | 11.1 | ... | 5.5 | ... | [illegible] |
| Grand Prix | 84.2 | ... | 96.7 | 7.0 | 90.7 | 5.9 | 90.8 | 7.1 | 21.6 | ... | ... | 78.4 | 100.0 | ... | 42.6 | 15.2 | ... | 12.7 | ... | [illegible] |
| Lemans | 45.3 | ... | 25.6 | 25.1 | 56.3 | ... | 70.7 | 5.0 | 27.2 | 11.8 | ... | 32.2 | ... | 25.4 | 5.0 | 1.1 | ... | 11.6 | ... | [illegible] |
| Firebird | 37.0 | ... | 92.0 | 23.5 | 57.8 | ... | 66.6 | 14.6 | 12.6 | 15.0 | 4.3 | 56.5 | ... | 14.1 | 8.6 | ... | ... | 21.8 | ... | [illegible] |
| Venture II | 11.8 | 1.3 | 83.2 | ... | 42.0 | ... | 35.1 | 1.3 | ... | 63.9 | ... | 10.9 | ... | 4.3 | ... | ... | ... | ... | ... | [illegible] |
| Oldsmobile | 67.0 | ... | 96.5 | 10.7 | 85.8 | 8.1 | 84.5 | 5.9 | 84.6 | 14.2 | ... | 1.2 | 32.3 | 26.2 | 35.0 | 16.4 | ... | 2.2 | ... | [illegible] |
| Toronado | 92.2 | ... | 97.1 | 2.2 | 95.5 | 22.9 | 76.2 | ... | 100.0 | ... | ... | ... | 100.0 | ... | 82.6 | 44.2 | ... | 100.0 | 2.8 | [illegible] |
| Cutlass | 53.8 | ... | 91.1 | 20.5 | 66.6 | ... | 77.8 | 4.8 | 6.6 | 71.2 | ... | 22.2 | ... | 16.5 | 5.5 | 1.9 | ... | 6.2 | ... | [illegible] |
| Buick | 65.3 | ... | 96.8 | 11.4 | 85.4 | 7.2 | 85.0 | 7.0 | 70.9 | 21.3 | ... | 6.3 | 40.9 | 32.3 | 42.1 | 23.5 | ... | 2.6 | 1.4 | [illegible] |
| Riviera | 69.7 | 3.5 | 98.8 | 2.4 | 96.7 | 13.2 | 85.8 | 16.0 | 23.1 | 4.2 | ... | 72.7 | 100.0 | ... | 100.0 | 44.2 | ... | 100.0 | 5.5 | [illegible] |
| Skylark | 47.2 | 1.7 | 92.0 | 30.9 | 83.5 | ... | 85.8 | 16.0 | ... | 76.9 | ... | 13.4 | ... | 20.0 | 10.5 | 1.5 | ... | 3.8 | ... | [illegible] |
| Cadillac | 94.8 | 0.7 | 99.5 | ... | 99.6 | 99.6 | ... | ... | 100.0 | ... | ... | ... | 100.0 | ... | 67.6 | 29.8 | ... | ... | 1.0 | [illegible] |
| Eldorado | 97.2 | 8.0 | 97.7 | ... | 97.6 | 99.8 | 75.2 | 4.2 | 100.0 | ... | ... | ... | 100.0 | ... | 85.7 | 51.8 | ... | ... | 6.0 | [illegible] |
| Tot. GM Units | 2,164,200 | 10,261 | 4,149,250 | 377,023 | 3,442,254 | 384,279 | 3,063,599 | 269,561 | 1,513,529 | 1,711,500 | 28,292 | 757,069 | 1,252,920 | 846,648 | 2,033,850 | 410,127 | 0 | 226,459 | 14,152 | 4,825,314 |
| % Tot. Output | 45.8 | 0.2 | 89.7 | 8.2 | 74.4 | 8.3 | 66.2 | 5.8 | 32.7 | 37.0 | 0.6 | 16.4 | 27.1 | 18.4 | 43.9 | 8.9 | 0.0 | 4.9 | 0.3 | |
| Ford | 47.9 | 0.1 | 84.3 | 4.9 | 80.2 | 3.6 | 82.0 | 3.3 | 25.6 | 59.0 | ... | ... | 44.0 | 3.1 | 6.6 | 5.3 | 4.8 | ... | ... | [illegible] |
| Torino | 40.7 | ... | 83.3 | 3.3 | 65.9 | ... | 68.1 | 3.3 | 26.2 | 55.3 | ... | 4.6 | 6.6 | 4.2 | ... | ... | ... | 3.7 | ... | [illegible] |
| Maverick | 19.5 | ... | 73.9 | ... | 36.5 | ... | 29.5 | ... | 13.7 | 55.8 | ... | ... | ... | 1.4 | ... | ... | 6.7 | ... | ... | [illegible] |
| Mustang | 32.3 | ... | 79.2 | 5.9 | 55.7 | ... | 48.5 | 4.2 | 38.1 | 44.7 | ... | 6.2 | 14.2 | 21.2 | 3.9 | ... | ... | 9.7 | ... | [illegible] |
| Thunderbird | 95.3 | 3.4 | 99.9 | ... | 97.7 | 29.6 | 69.3 | 7.1 | 79.3 | 20.7 | ... | ... | 100.0 | ... | 74.5 | 35.6 | 27.1 | ... | 5.8 | [illegible] |
| Pinto | 5.9 | 1.7 | 74.2 | ... | 34.3 | ... | 18.4 | ... | ... | 79.7 | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | [illegible] |
| Mercury | 73.5 | 0.2 | 94.8 | 1.5 | 92.0 | 21.9 | 71.6 | 5.9 | 75.4 | 17.0 | ... | ... | 66.0 | 9.6 | 36.0 | 25.9 | 14.9 | 6.9 | ... | [illegible] |
| Marquis | 62.9 | ... | 89.6 | 2.4 | 73.0 | ... | 76.3 | 3.4 | 38.5 | 48.1 | ... | ... | 4.4 | 24.0 | ... | ... | ... | 1.9 | ... | [illegible] |
| Montego | 78.9 | 1.0 | 98.0 | 2.1 | 81.4 | ... | 81.2 | 3.5 | 43.0 | 45.0 | ... | 5.3 | ... | 62.4 | 21.9 | ... | ... | 4.9 | ... | [illegible] |
| Cougar | 27.5 | ... | 83.3 | ... | 38.5 | ... | 35.3 | ... | ... | 59.3 | ... | ... | ... | 1.6 | ... | ... | ... | ... | ... | [illegible] |
| Comet | 92.8 | 0.8 | 100.0 | ... | 100.0 | 100.0 | ... | 12.6 | 88.0 | 20.0 | ... | ... | 100.0 | ... | 77.3 | 63.3 | 32.4 | ... | 7.7 | [illegible] |
| Lincoln | 100.0 | 8.1 | 100.0 | ... | 100.0 | 100.0 | ... | 15.8 | 100.0 | ... | ... | ... | 100.0 | ... | 89.5 | 73.8 | 58.1 | ... | 100.0 | [illegible] |
| Mark IV | 100.0 | 8.1 | 100.0 | ... | 100.0 | 100.0 | ... | ... | 100.0 | ... | 0 | 30,765 | 655,911 | 156,725 | 249,268 | 171,341 | 127,273 | 29,416 | 56,257 | 2,423,245 |
| Tot. Ford Units | 1,086,731 | 15,252 | 2,227,972 | 66,595 | 1,662,079 | 176,704 | 1,492,795 | 80,979 | 712,054 | 991,893 | 0 | 30,765 | 655,911 | 156,725 | 249,268 | 171,341 | 127,273 | 29,416 | 56,257 | 2,423,245 |
| % Tot. Output | 41.3 | 0.6 | 85.0 | 2.5 | 63.0 | 6.7 | 56.7 | 3.1 | 27.0 | 37.7 | 0.0 | 1.2 | 24.9 | 6.0 | 9.5 | 6.5 | 4.8 | 1.1 | 2.2 | |
| Fury | 43.9 | 0.1 | 89.0 | 9.8 | 76.5 | ... | 84.6 | 6.2 | ... | 76.7 | ... | 0.8 | ... | 48.9 | 1.3 | 35.3 | 5.0 | 0.5 | ... | [illegible] |
| Satellite | 45.6 | 0.1 | 63.8 | 13.5 | 57.2 | ... | 65.1 | 6.0 | 14.7 | 56.5 | ... | 10.2 | ... | 35.5 | 0.4 | ... | ... | 4.1 | ... | [illegible] |
| Barracuda | 51.3 | 0.4 | 82.5 | 18.4 | 37.6 | ... | 33.8 | 22.7 | ... | 32.0 | ... | 53.5 | ... | 8.7 | ... | ... | ... | 41.5 | ... | [illegible] |
| Valiant | 42.9 | 0.1 | 56.3 | 17.4 | 24.5 | ... | 31.9 | 2.8 | ... | 50.4 | ... | 8.0 | ... | ... | ... | ... | ... | 4.6 | ... | [illegible] |
| Chrysler | 62.4 | 0.1 | 95.3 | 4.8 | 90.6 | 11.1 | 82.0 | 7.7 | 92.8 | 4.0 | ... | 2.2 | 27.8 | 16.2 | 17.0 | 27.0 | 32.3 | 0.9 | ... | [illegible] |
| Imperial | 100.0 | 1.4 | 100.0 | ... | 100.0 | 83.8 | 16.2 | 22.9 | 100.0 | ... | ... | ... | 100.0 | ... | 77.5 | 52.3 | 59.2 | ... | 4.0 | [illegible] |
| Polara | 61.3 | ... | 65.8 | 6.0 | 83.2 | ... | 81.4 | 5.0 | 5.5 | 78.5 | ... | 2.2 | ... | 62.5 | 4.4 | 45.3 | 15.6 | 3.9 | ... | [illegible] |
| Coronet/Charger | 49.1 | 0.3 | 75.0 | 0.7 | 70.9 | ... | 69.6 | 5.2 | 12.0 | 62.7 | ... | 12.7 | ... | 52.9 | 1.2 | ... | ... | 6.1 | ... | [illegible] |
| Challenger | 73.4 | 0.6 | 87.9 | 2.5 | 57.6 | ... | 41.3 | 2.7 | ... | 44.8 | ... | 45.3 | ... | 10.6 | ... | ... | ... | 25.7 | ... | [illegible] |
| Satellite | 69.3 | 0.2 | 85.9 | 15.5 | 33.1 | ... | 46.8 | 13.7 | ... | 79.5 | ... | 5.7 | ... | ... | ... | ... | ... | 3.9 | ... | [illegible] |
| Tot. Chrysler Units | 760,286 | 1,833 | 1,061,158 | 134,427 | 822,543 | 35,963 | 852,530 | 76,108 | 266,406 | 726,441 | 0 | 88,334 | 72,718 | 396,043 | 89,451 | 235,321 | 116,253 | 84,453 | 622 | 1,221,124 |
| % Tot. Output | 43.0 | 0.1 | 79.4 | 10.1 | 62.5 | 2.7 | 64.0 | 5.7 | 20.0 | 54.6 | 0.0 | 6.6 | 5.5 | 29.8 | 44.7 | 17.7 | 8.7 | 6.1 | 0.1 | |
| Matador | 15.0 | ... | 51.6 | 16.7 | 32.0 | ... | 42.5 | 8.9 | ... | 46.0 | ... | 1.1 | ... | 15.9 | 3.0 | 1.1 | 25.6 | 1.9 | ... | [illegible] |
| Hornet | 5.8 | 0.5 | 47.4 | 7.7 | 36.2 | ... | 37.3 | 3.6 | ... | 41.1 | ... | 7.5 | ... | 12.8 | 3.5 | ... | 32.9 | ... | ... | [illegible] |
| Ambassador | 33.0 | ... | 69.0 | 16.3 | 69.4 | ... | 92.2 | 14.5 | 58.0 | 14.8 | ... | 1.1 | ... | 40.5 | 16.1 | 9.9 | 58.9 | 9.5 | ... | [illegible] |
| Javelin | 51.6 | ... | 65.0 | 21.7 | 35.8 | ... | 52.0 | 12.9 | ... | 56.0 | 11.9 | 14.5 | ... | 37.3 | 9.6 | ... | ... | 12.6 | ... | [illegible] |
| Gremlin | ... | 1.8 | 27.4 | 8.9 | 22.3 | ... | 26.7 | 3.1 | ... | 15.7 | ... | 42.8 | ... | ... | 1.6 | ... | ... | ... | ... | [illegible] |
| Tot. AMC Units | 43,851 | 1,435 | 125,756 | 33,802 | 97,731 | 0 | 125,161 | 19,236 | 25,712 | 85,635 | 1,200 | 36,518 | 0 | 45,309 | 14,253 | 4,559 | 65,879 | 3,761 | 0 | 259,105 |
| % Tot. Output | 16.9 | 0.6 | 48.5 | 13.0 | 37.7 | 0.0 | 43.3 | 7.4 | 9.9 | 33.1 | 0.5 | 14.1 | 0.0 | 17.7 | 5.7 | 1.9 | 25.4 | 2.4 | 0.0 | |
| TOT. IND. UNITS | 4,060,121 | 29,331 | 7,574,141 | 612,647 | 6,034,657 | 596,876 | 5,534,156 | 445,984 | 2,517,701 | 3,515,719 | 29,512 | 912,639 | 1,981,629 | 1,444,935 | 2,354,457 | 821,200 | 309,452 | 319,719 | 71,231 | 8,849,618 |
| % TOT. OUTPUT | 44.3 | 0.3 | 85.6 | 6.9 | 68.2 | 6.8 | 62.5 | 5.0 | 28.4 | 39.7 | 0.3 | 10.3 | 19.9 | 14.5 | 23.6 | 9.3 | 3.5 | 3.6 | 0.8 | |

Note: West of Chrysler Corp. and Ford Motor Co. installation rates are based on North American production, but the totals shown for Chrysler in the right hand column are only for U.S. production. General Motors Corp. and American Motors Corp. rates are based only on U.S. production.



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DETROIT, MICH.

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# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '73 MODEL CARS

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio All Only | Radio Am-Fm Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4 Wheel Disc | Disc Brakes Manual | Power Door Locks | Power Seats 2-Way Only | Power Seats 6-Way Only | Total Power Windows | Bucket Seats | Vinyl Roofs (Non-Convert.) | Rates Based On Total Output of: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 98.5 | | 79.9 | 19.7 | 0.5 | 66.0 | 16.2 | 5.3 | 4.9 | 100.0 | .... | 100.0 | | 10.7 | .... | 5.7 | 29.6 | | 39.6 | 972,653 |
| Corvette | 98.5 | 41.2 | 58.8 | 98.2 | .... | .... | 57.8 | 41.0 | .... | 98.5 | .... | 79.3 | 20.7 | .... | .... | .... | 41.0 | 100.0 | .... | 21,644 |
| Chevelle | 98.6 | 0.6 | 27.1 | 67.9 | 5.0 | 74.7 | 10.1 | 1.5 | 5.1 | 98.4 | .... | 89.6 | 10.4 | 2.1 | .... | 0.6 | 2.0 | 8.0 | 39.6 | 204,742 |
| Nova | 98.6 | 2.2 | 38.6 | 32.6 | 28.8 | 82.6 | 9.2 | .... | .... | 96.4 | 10.0 | 21.0 | .... | .... | .... | .... | .... | 15.3 | 39.9 | .... |
| Monte Carlo | 98.6 | .... | 47.4 | 52.6 | .... | 40.3 | 21.2 | 14.6 | 19.9 | 100.0 | .... | 100.0 | .... | 11.8 | .... | 4.5 | 22.9 | 100.6 | 39.2 | 247,115 |
| Camaro | 98.6 | 11.3 | 38.5 | 61.5 | 3.7 | 69.2 | 26.2 | .... | .... | 100.0 | .... | 88.1 | 11.6 | .... | .... | .... | 9.2 | 100.0 | 39.4 | .... |
| Vega 2300 | 98.6 | 23.6 | .... | .... | .... | 80.8 | 10.0 | .... | .... | .... | .... | .... | 100.0 | .... | .... | .... | .... | 100.0 | 39.9 | 421,188 |
| Vega | 100.0 | .... | 100.0 | .... | .... | 57.4 | 19.1 | 15.5 | 7.3 | 100.0 | .... | 100.0 | .... | .... | .... | .... | .... | .... | 39.6 | 972,653 |
| Chevrolet | 100.0 | .... | 80.1 | 19.9 | .... | 26.9 | 10.6 | 49.0 | 26.1 | 100.0 | .... | 100.0 | .... | 15.3 | 1.1 | 16.2 | 38.0 | .... | 49.6 | 874,795 |
| El Camino | 98.7 | 1.0 | 39.7 | 60.6 | 1.7 | 66.5 | 16.3 | 10.2 | 8.1 | 98.3 | .... | 93.6 | 6.4 | 4.0 | .... | 3.5 | 10.3 | 33.2 | 39.6 | 248,765 |
| Blazer | 89.2 | 9.1 | 69.5 | 27.5 | 3.0 | 57.0 | 22.0 | 15.7 | 14.0 | 99.6 | .... | 88.2 | 11.8 | 4.1 | .... | .... | 11.6 | 100.0 | 49.0 | 4,213 |
| Jimmy | 92.6 | 1.4 | .... | 72.8 | 27.2 | 66.9 | 5.6 | .... | .... | 84.9 | 13.0 | 23.1 | .... | .... | .... | .... | .... | 9.3 | 39.6 | 972,653 |
| Oldsmobile | 100.0 | .... | 100.0 | .... | .... | 47.8 | 10.8 | .... | .... | 100.0 | .... | 100.0 | .... | 34.6 | 1.7 | 30.4 | 46.6 | .... | 10.5 | 98,520 |
| Delmonte 88 | 100.0 | .... | 100.0 | .... | .... | 14.1 | 5.3 | 35.3 | 10.5 | 100.0 | .... | 100.0 | .... | .... | .... | .... | .... | .... | 39.1 | 417,332 |
| Cutlass | 100.0 | 0.6 | 100.0 | .... | .... | 64.9 | 12.6 | 78.6 | 27.9 | 100.0 | .... | 100.0 | .... | 77.8 | .... | 93.1 | 98.7 | .... | 49.4 | 6,155 |
| Omega | 100.0 | .... | .... | 68.1 | 31.9 | 85.6 | 4.8 | 17.0 | 10.2 | 99.7 | .... | 97.2 | 2.8 | 5.0 | .... | 3.9 | 9.7 | 31.3 | 39.6 | 403,513 |
| Buick | 100.0 | .... | .... | .... | .... | 41.3 | 19.1 | .... | .... | 87.4 | 21.3 | 26.5 | .... | .... | .... | .... | .... | 15.3 | 49.0 | 6,155 |
| Century | 100.0 | .... | 60.3 | 39.7 | .... | 41.3 | 19.1 | 22.9 | 13.1 | 100.0 | .... | 100.0 | .... | 32.6 | 0.2 | 43.9 | 57.5 | .... | 49.0 | 6,155 |
| Apollo | 100.0 | .... | 59.4 | 40.6 | .... | 8.8 | 9.0 | 46.4 | 34.9 | 100.0 | .... | 100.0 | .... | 57.4 | .... | 67.6 | 97.2 | .... | 49.1 | 30,765 |
| Skylark | 100.0 | 0.1 | 69.1 | 30.9 | .... | 61.8 | 16.5 | 9.9 | 8.1 | 99.4 | .... | 99.1 | 3.9 | 5.6 | .... | 7.2 | 10.6 | 4.6 | 39.4 | 252,459 |
| Gran Sport | 100.0 | .... | .... | 92.7 | 7.3 | 87.9 | 7.1 | .... | .... | 95.6 | 41.0 | 26.4 | .... | .... | .... | .... | .... | .... | 39.6 | 24,783 |
| Cadillac | 100.0 | .... | 100.0 | .... | .... | .... | 19.4 | 80.3 | .... | 100.0 | .... | 100.0 | .... | 91.9 | 2.7 | 96.6 | 100.0 | .... | 39.6 | 261,176 |
| Eldorado | 100.0 | .... | 100.0 | .... | .... | .... | 6.2 | 93.7 | .... | 100.0 | .... | 100.0 | .... | 95.7 | 1.2 | 97.8 | 100.0 | .... | 39.7 | 31,901 |
| Tot. GM Units | 5,223,237 | 191,154 | 3,412,292 | 1,642,203 | 60,675 | 3,226,973 | 812,712 | 943,432 | 475,691 | 5,060,717 | 75,247 | 4,601,978 | 530,644 | 925,783 | 19,723 | 903,077 | 1,560,990 | 1,154,667 | 2,633,[illegible] | 5,223,237 |
| % Tot. Output | 99.4 | 3.8 | 61.8 | 29.6 | 1.4 | 57.9 | 14.6 | 18.9 | 7.3 | 93.9 | 1.4 | 92.6 | 9.5 | 16.6 | 0.4 | 17.2 | 28.4 | 22.9 | 47.4 | — |
| Ford | 100.0 | .... | 36.9 | 64.1 | .... | 71.7 | .... | 18.6 | 3.8 | 100.0 | .... | 100.0 | .... | 11.5 | .... | 6.8 | 9.4 | .... | 49.7 | 808,800 |
| Pinto | 99.2 | 0.4 | 90.9 | .... | 1.1 | 81.6 | .... | 11.0 | .... | 97.9 | .... | 82.2 | 17.8 | 1.7 | .... | 1.0 | 21.2 | 4.5 | 41.6 | 451,427 |
| Maverick | 98.3 | .... | .... | 39.5 | 60.5 | 55.4 | .... | 4.0 | .... | 74.5 | .... | .... | .... | .... | .... | .... | .... | 3.0 | 49.0 | 357,373 |
| Mustang | 98.4 | 2.9 | 9.6 | 90.6 | 5.8 | 64.9 | .... | 15.9 | 8.2 | 92.9 | .... | 77.9 | .... | .... | .... | .... | .... | 100.0 | 49.0 | 451,427 |
| Thunderbird | 100.0 | .... | 22.7 | 77.3 | .... | 6.2 | .... | 62.9 | 28.9 | 100.0 | .... | 100.0 | .... | 61.5 | .... | 55.9 | 99.2 | 4.6 | 39.4 | 62,711 |
| Ranchero | 100.0 | 45.9 | .... | .... | .... | 80.2 | 8.0 | 2.5 | .... | .... | .... | .... | 89.4 | .... | .... | .... | .... | 100.0 | 39.6 | 24,783 |
| Torino | 100.0 | .... | 62.0 | 38.0 | .... | 42.6 | .... | 41.3 | 14.2 | 100.0 | .... | 100.0 | .... | 31.5 | .... | 50.3 | 72.1 | .... | 49.0 | 451,427 |
| Montego | 99.7 | 0.2 | 1.6 | 99.2 | 0.8 | 63.7 | .... | 28.3 | .... | 99.4 | .... | 77.7 | 22.3 | 5.7 | .... | 6.3 | 17.6 | 7.0 | 39.7 | 182,709 |
| Cougar | 99.3 | 0.7 | 92.3 | 4.7 | .... | 40.5 | .... | 42.0 | 15.6 | 99.1 | .... | 100.0 | .... | .... | .... | 8.4 | 14.7 | 100.0 | 41.8 | 156,315 |
| Comet | 98.1 | .... | .... | 45.9 | 54.1 | 84.2 | .... | 7.9 | .... | 75.9 | .... | .... | .... | .... | .... | .... | .... | 55.0 | 39.6 | 65,368 |
| Maverick | 100.0 | .... | 100.0 | .... | .... | 6.4 | .... | 55.2 | 40.4 | 100.0 | .... | 100.0 | .... | 92.7 | 3.5 | 96.5 | 100.0 | .... | 39.6 | 24,783 |
| Mark IV | 100.0 | .... | 100.0 | .... | .... | 1.8 | .... | 20.6 | 57.6 | 100.0 | .... | 100.0 | .... | 95.4 | .... | 100.0 | 100.0 | .... | 39.6 | 24,783 |
| Tot. Ford Units | 2,855,319 | 220,189 | 1,874,965 | 1,043,206 | 200,771 | 1,907,240 | 13,553 | 503,159 | 99,120 | 2,220,592 | .... | 1,854,661 | 520,758 | 425,623 | 2,052 | 376,115 | 773,732 | 772,216 | 1,000,[illegible] | 2,763,134 |
| % Tot. Output | 53.5 | 7.9 | 33.6 | 37.6 | 7.5 | 64.4 | 0.5 | 18.1 | 3.6 | 80.0 | .... | 66.8 | 18.7 | 14.6 | 0.1 | 13.5 | 27.8 | 27.7 | 47.6 | — |
| Rally | 100.0 | .... | 22.0 | 77.0 | .... | 71.8 | 10.3 | 5.8 | 0.2 | 100.0 | .... | 100.0 | .... | 5.1 | .... | 3.6 | 24.1 | 1.5 | 42.5 | 210,066 |
| Sportabout | 99.4 | 1.2 | 60.6 | 14.2 | 3.8 | 83.2 | 7.3 | 6.0 | 0.2 | 96.5 | .... | 87.1 | 12.9 | .... | .... | .... | 13.5 | 20.5 | 39.6 | 194,061 |
| Validant | 99.4 | 9.9 | 89.4 | 35.6 | .... | 77.7 | .... | 16.0 | 3.9 | 97.7 | .... | 76.5 | 21.5 | .... | .... | .... | .... | 100.0 | 39.6 | 24,783 |
| Charger | 98.4 | 0.5 | 24.9 | .... | 75.1 | 66.2 | .... | .... | .... | 71.9 | .... | 91.0 | 9.8 | .... | .... | .... | .... | .... | 39.6 | 24,783 |
| Coronet | 100.0 | .... | 52.2 | 1.8 | .... | 97.2 | 9.7 | 25.0 | 6.3 | 100.0 | .... | 100.0 | .... | 22.9 | .... | 26.7 | 46.0 | .... | 39.6 | 924,155 |
| Imperial | 100.0 | .... | 100.0 | .... | .... | .... | 11.0 | 45.1 | 43.6 | 100.0 | .... | 100.0 | .... | 91.1 | .... | 92.5 | 100.0 | 12.1 | 39.6 | 156,315 |
| Polara | 100.0 | .... | 58.9 | 80.1 | .... | 66.4 | 15.6 | 9.1 | 0.4 | 100.0 | .... | 100.0 | .... | 12.7 | .... | 12.4 | 28.9 | 2.5 | 39.6 | 65,368 |
| Custom Charger | 98.8 | 0.7 | 73.1 | 25.4 | 3.5 | 73.1 | 11.1 | 9.5 | 0.4 | 97.7 | .... | 93.9 | 10.0 | .... | .... | .... | 17.8 | 22.5 | 39.7 | 182,709 |
| Challenger | 97.9 | 6.0 | 66.6 | 33.2 | .... | 70.6 | .... | 15.6 | 0.5 | 93.1 | .... | 76.5 | 23.5 | .... | .... | .... | .... | 100.0 | 39.6 | 24,783 |
| Valiant | 99.7 | 0.5 | 54.5 | .... | .... | 55.2 | 4.0 | .... | .... | 72.1 | .... | 70.1 | 15.9 | .... | .... | .... | .... | 5.1 | 39.6 | 252,459 |
| Tot. Chrysler Units | 1,527,017 | 10,035 | 833,592 | 316,712 | 415,504 | 1,206,768 | 123,000 | 119,605 | 21,038 | 1,451,[illegible] | .... | 1,100,[illegible] | 82,573 | 89,219 | .... | 113,[illegible] | 250,[illegible] | 143,[illegible] | 1,029,[illegible] | 1,[illegible] |
| % Tot. Output | 98.8 | 0.7 | 53.9 | 20.5 | 26.9 | 76.1 | 7.8 | 7.5 | 1.4 | 93.9 | .... | 69.4 | 5.4 | 5.8 | .... | 7.2 | 15.9 | 10.9 | 66.7 | — |
| Hunter | 97.8 | .... | .... | 77.5 | 20.5 | 70.6 | .... | 2.8 | .... | 91.6 | 23.9 | 29.1 | .... | .... | .... | .... | 11.1 | 2.9 | 27.1 | 52,772 |
| Arrow | 100.0 | .... | .... | 11.9 | 97.0 | 60.5 | .... | 5.0 | .... | 65.1 | 6.5 | 7.5 | 0.1 | .... | .... | .... | .... | 1.9 | 0.8 | 123,104 |
| Ambassador | 100.0 | 15.0 | 60.0 | 40.0 | .... | 74.0 | .... | 12.4 | .... | 100.0 | .... | 100.0 | .... | .... | .... | .... | 20.5 | 10.7 | 49.0 | 6,155 |
| Gremlin | 97.0 | 2.9 | 0.8 | 99.2 | 7.2 | 64.0 | .... | 14.1 | 0.6 | 100.0 | 15.7 | 37.4 | 5.7 | .... | .... | .... | .... | 100.0 | 39.6 | 24,783 |
| Hornet | 99.4 | .... | .... | 11.4 | 88.6 | 58.5 | .... | 3.0 | .... | 77.0 | .... | 74.6 | 4.0 | .... | .... | .... | .... | 3.1 | 39.6 | 252,459 |
| Tot. AMC Units | 270,[illegible] | 1,[illegible] | 5,[illegible] | 102,[illegible] | 100,237 | 242,[illegible] | .... | 16,[illegible] | 2,702 | 229,[illegible] | 25,[illegible] | 221,[illegible] | 15,771 | .... | .... | .... | .... | .... | .... | .... |
| % Tot. Output | 99.1 | 0.6 | 43.5 | 37.8 | 36.9 | 89.1 | .... | 6.2 | 0.9 | 77.4 | 9.9 | 75.7 | 4.9 | .... | .... | .... | 5.7 | 2.9 | 1.9 | — |
| TOTAL DOMESTIC | 9,855,[illegible] | 422,[illegible] | 5,[illegible] | 3,[illegible] | 860,[illegible] | 6,[illegible] | 949,[illegible] | 1,[illegible] | 598,[illegible] | 9,[illegible] | 100,[illegible] | 7,[illegible] | 1,[illegible] | 1,[illegible] | 21,[illegible] | 1,[illegible] | 2,[illegible] | 2,[illegible] | 3,[illegible] | [illegible] |
| % Tot. Output | 70.4 | 4.1 | 52.1 | 31.4 | 8.6 | [illegible] | 13.3 | 16.1 | 10.3 | 87.7 | 1.0 | 74.5 | 11.2 | 15.8 | 0.2 | 14.1 | 27.7 | 21.4 | 53.9 | — |

Note: Only Following Car Lines Production Figures Include Units Sold in Canada for U.S. sale. Pinto and Vega engines are 122cu in four cylinder. Torino V-8 engine standard (Gran Sport optional). Vega Sport Coupe has standard bucket seats. Rear window defogger reduces electricity. Heats rear window on some models. Percent installation rates for Reclining Front Seats are as follows: Chevrolet 41.1, Corvette 39.9, Chevelle 39.6, Nova 39.6, Monte Carlo 39.9, Camaro 39.2, Vega 39.9, Chevrolet 39.6, El Camino 39.6, Blazer 49.0, Jimmy 39.6, Oldsmobile 10.5, Delmonte 88 39.1, Cutlass 49.4, Omega 39.6, Buick 49.0, Century 49.0, Apollo 49.1, Skylark 39.4, Gran Sport 39.6, Cadillac 39.6, Eldorado 39.7, Ford 49.7, Pinto 41.6, Maverick 49.0, Mustang 41.6, Thunderbird 39.4, Ranchero 39.6, Torino 49.0, Montego 39.7, Cougar 41.8, Comet 39.6, Maverick 39.6, Mark IV 39.6, Rally 42.5, Sportabout 39.6, Validant 39.6, Charger 39.6, Coronet 39.6, Polara 39.6, Custom Charger 39.7, Challenger 39.6, Valiant 39.6, Hunter 27.1, Ambassador 49.0, Gremlin 39.6, Hornet 39.6, Tot. Chrysler Units 1,029,[illegible], Tot. AMC Units [illegible], TOTAL DOMESTIC [illegible].

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[illegible] [Ct X 6, p 13]

F-135b

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '73 MODEL CARS — (Continued)

| | Sun Roofs | Steel-Belted Radial Ply Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited-Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Adjustable Steering Col. | Speed Mtg. Device | Dual Exhausts | Skid Control Device | Rear Window Defogger | Remote Control Outside Mirror | Opera Lamps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | ... | ... | 4.0 | 86.2 | 3.0 | 84.3 | 4.0 | 26.7 | 58.0 | ... | ... | 26.1 | 14.1 | 19.0 | 8.9 | 12.2 | ... | ... | ... | ... |
| Corvette | ... | 100.0 | ... | 100.0 | ... | 70.8 | 94.1 | 94.3 | 5.7 | ... | 0.0 | 100.0 | ... | 59.0 | ... | 100.0 | ... | ... | ... | ... |
| Chevelle | 0.3 | ... | 2.8 | 72.8 | ... | 66.2 | 4.5 | 15.1 | 55.6 | ... | 9.2 | ... | 15.5 | 9.2 | ... | 11.2 | ... | ... | ... | ... |
| Nova | 0.9 | ... | 1.6 | 45.9 | ... | 34.4 | 4.0 | ... | 41.5 | ... | 23.0 | ... | 7.4 | 2.1 | ... | 4.5 | ... | ... | ... | ... |
| Monte Carlo | 2.7 | 98.3 | 2.9 | 92.8 | ... | 93.7 | 6.2 | 19.7 | 17.3 | 32.5 | 30.5 | 100.0 | ... | 59.2 | 10.3 | 15.5 | ... | 22.8 | ... | ... |
| Camaro | ... | ... | 1.5 | 70.5 | ... | 51.2 | 19.4 | ... | 26.8 | 29.2 | 25.3 | 30.4 | 15.9 | 17.6 | ... | 25.6 | ... | 19.7 | ... | ... |
| Vega 2300 | ... | 2.0 | 0.5 | 43.1 | ... | 25.7 | 4.0 | ... | 63.5 | ... | 29.1 | ... | 31.6 | ... | ... | ... | ... | 15.7 | ... | ... |
| Pontiac | ... | 3.6 | 12.3 | 82.6 | 4.8 | 87.3 | 5.2 | 19.2 | 56.0 | ... | 22.2 | 26.7 | 23.9 | 28.2 | 14.4 | 7.2 | ... | 21.9 | ... | ... |
| Grand Prix | 4.0 | 38.4 | 4.9 | 92.6 | 8.1 | 84.1 | 8.9 | 17.0 | 6.5 | ... | 76.5 | 100.0 | ... | 50.4 | 21.0 | 100.0 | ... | 31.0 | ... | ... |
| Lemans | 1.1 | 17.3 | 18.6 | 68.9 | 1.1 | 78.3 | 5.7 | 12.0 | 55.7 | ... | 45.3 | 17.3 | ... | 22.6 | 13.6 | 3.4 | ... | 13.3 | ... | ... |
| Firebird | ... | 6.2 | 14.2 | 60.5 | ... | 66.1 | 20.1 | 11.4 | 11.4 | 10.4 | 59.8 | ... | ... | 13.5 | 15.2 | ... | ... | 17.5 | ... | ... |
| Ventura | ... | ... | 22.1 | 32.3 | ... | 28.7 | 2.3 | ... | 41.8 | ... | 20.4 | ... | ... | 6.4 | 1.5 | 4.4 | ... | 7.2 | ... | ... |
| Oldsmobile | ... | 0.2 | 4.7 | 91.9 | 9.2 | 84.0 | 5.7 | 84.3 | 15.7 | ... | ... | 33.2 | 25.2 | 44.2 | 26.4 | 4.5 | ... | 37.4 | ... | ... |
| Toronado | ... | 1.3 | ... | 99.4 | 26.3 | 73.0 | ... | 80.2 | 19.8 | ... | ... | 100.0 | ... | 89.1 | 60.5 | 100.0 | 3.2 | 61.7 | ... | ... |
| Cutlass | 7.3 | 4.6 | 9.9 | 79.8 | ... | 69.1 | 5.0 | ... | 61.3 | ... | 22.9 | ... | ... | 24.3 | 15.9 | 3.0 | ... | 19.7 | ... | ... |
| Omega | ... | ... | ... | 51.4 | ... | 41.3 | 2.0 | ... | 63.9 | ... | 13.8 | ... | ... | 4.5 | 2.1 | ... | ... | 5.2 | ... | ... |
| Buick | 0.2 | 9.4 | 8.9 | 83.9 | 8.7 | 85.7 | 6.5 | 66.4 | 22.8 | ... | 9.4 | 39.0 | 35.6 | 27.2 | 20.1 | 4.6 | 1.8 | 23.9 | ... | ... |
| Riviera | 3.5 | 36.4 | 1.9 | 97.2 | 17.3 | 82.0 | 12.3 | 16.8 | 7.4 | ... | 75.8 | 100.0 | ... | 100.0 | 53.3 | 100.0 | 5.7 | 71.9 | ... | ... |
| Century | 1.1 | 1.9 | 18.6 | 70.3 | ... | 62.0 | 4.9 | 30.7 | 59.4 | ... | 16.6 | ... | 22.3 | 27.3 | 4.4 | 9.1 | ... | 21.1 | ... | ... |
| Apollo | ... | ... | ... | 24.8 | ... | 55.4 | 1.5 | ... | 77.1 | ... | 12.9 | ... | 31.4 | 7.6 | ... | ... | ... | 3.7 | ... | ... |
| Cadillac | 1.1 | 25.8 | ... | 99.6 | 99.7 | ... | 7.4 | 100.0 | ... | ... | ... | 100.0 | ... | 73.2 | 27.0 | ... | 1.5 | 33.1 | ... | ... |
| Eldorado | 8.9 | 28.7 | ... | 99.7 | 99.8 | ... | ... | 100.0 | ... | ... | ... | 100.0 | ... | 53.7 | 27.0 | ... | 2.6 | 52.2 | ... | ... |
| Tot. GM Units | 63,547 | 609,018 | 305,251 | 4,390,673 | 466,549 | 3,[illegible]12 | 224,691 | 1,537,577 | 2,317,518 | 127,511 | 1,011,717 | 1,672,517 | 995,326 | 1,462,[illegible]72 | 665,[illegible]72 | 706,072 | 13,5[illegible]2 | 1,220,[illegible]11 | 2,94[illegible]21 | 5,[illegible]13 |
| % Tot. Output | 1.2 | 11.0 | 5.5 | 79.0 | 8.4 | 3.9 | 5.3 | 27.6 | 41.6 | 2.3 | 18.1 | 30.1 | 17.9 | 26.3 | 12.0 | 12.1 | 0.3 | 18.9 | 22.9 | 1.1 |
| Ford | 0.2 | 19.6 | 4.7 | 80.2 | 4.6 | 84.8 | 3.2 | 21.5 | 60.5 | ... | ... | 65.0 | 2.7 | 9.3 | 7.2 | ... | ... | 16.1 | ... | ... |
| Torino | ... | 0.8 | 4.5 | 70.9 | ... | 76.0 | 2.3 | 22.4 | 57.9 | ... | 5.2 | 3.3 | 0.6 | ... | ... | 2.5 | ... | 5.4 | ... | ... |
| Maverick | ... | 25.8 | ... | 50.7 | ... | 42.3 | ... | 10.2 | 70.5 | ... | 0.9 | ... | ... | ... | ... | ... | ... | 4.3 | ... | ... |
| Mustang | ... | 5.3 | 1.0 | 61.6 | ... | 56.2 | 4.3 | 21.0 | 51.2 | ... | 7.5 | 13.7 | 30.4 | 5.6 | ... | 3.4 | ... | 6.3 | ... | ... |
| Thunderbird | 4.8 | 100.0 | ... | 97.9 | 37.0 | 62.4 | 6.9 | 15.2 | 84.8 | ... | ... | 100.0 | ... | 75.3 | 50.1 | ... | 5.9 | 45.9 | ... | ... |
| Pinto | 2.6 | 13.6 | ... | 42.3 | ... | 25.9 | ... | ... | 71.5 | ... | 4.0 | ... | ... | ... | ... | ... | ... | 4.8 | ... | ... |
| Mercury | 0.3 | 93.0 | 1.3 | 94.1 | 24.5 | 71.2 | 6.5 | 74.9 | 18.3 | ... | ... | 68.3 | 10.2 | 42.3 | 32.7 | ... | 1.4 | 25.4 | ... | ... |
| Montego | 1.1 | 9.3 | 3.2 | 80.2 | ... | 82.4 | 3.1 | 41.9 | 48.8 | ... | 0.4 | 2.8 | 52.8 | ... | ... | 1.9 | ... | ... | ... | ... |
| Cougar | 1.6 | 17.7 | 0.8 | 85.4 | ... | 84.5 | 4.2 | 45.4 | 45.6 | ... | 5.4 | ... | 70.5 | 28.0 | ... | ... | ... | ... | ... | ... |
| Comet | ... | 25.5 | ... | 50.4 | ... | 45.7 | ... | 24.4 | 66.3 | ... | 1.8 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Lincoln | 1.4 | 100.0 | ... | 100.0 | 100.0 | ... | 13.1 | 77.1 | 22.9 | ... | ... | 100.0 | ... | 83.1 | 75.9 | ... | 7.0 | 51.4 | ... | ... |
| Mark IV | 10.0 | 100.0 | ... | 100.0 | 100.0 | ... | 13.9 | 100.0 | ... | ... | ... | 100.0 | ... | 92.0 | 90.5 | ... | 100.0 | 57.9 | ... | ... |
| Tot. Ford Units | 26,233 | 724,005 | 67,747 | 1,591,873 | 240,973 | 1,690,643 | 83,671 | 719,735 | 1,599,535 | ... | 64,456 | 993,317 | 215,823 | 352,731 | 262,213 | 14,813 | 179,412 | 362,716 | 1,775,[illegible] | [illegible] |
| % Tot. Output | 0.9 | 26.0 | 2.4 | 71.4 | 8.6 | 60.7 | 3.0 | 25.8 | 57.4 | ... | 2.3 | 35.6 | 7.7 | 12.6 | 9.4 | 0.5 | 6.1 | 13.0 | 63.7 | ... |
| Fury | 0.1 | 2.2 | 8.9 | 80.8 | ... | 87.0 | 6.6 | 4.5 | 70.9 | ... | 2.0 | 16.3 | 40.0 | 2.9 | 12.4 | ... | ... | 10.8 | [illegible] | [illegible] |
| Satellite | 0.9 | 0.4 | 13.7 | 61.4 | ... | 68.6 | 5.8 | 13.3 | 55.0 | 5.8 | 10.2 | ... | 7.2 | ... | ... | 9.7 | ... | 10.3 | [illegible] | [illegible] |
| Barracuda | ... | ... | ... | 52.5 | ... | 52.5 | 21.4 | ... | 22.4 | ... | 53.1 | ... | 31.6 | ... | ... | 38.6 | ... | 9.0 | [illegible] | [illegible] |
| Valiant | 2.7 | ... | 17.6 | 31.0 | ... | 38.4 | 2.3 | ... | 76.1 | ... | 6.7 | ... | ... | ... | ... | 3.7 | ... | 6.7 | [illegible] | [illegible] |
| Chrysler | 0.2 | 6.2 | 2.7 | 94.4 | 11.5 | 93.3 | 6.7 | 90.2 | 6.2 | ... | 3.6 | 11.5 | 53.4 | 19.5 | 25.7 | ... | ... | 40.9 | [illegible] | [illegible] |
| Imperial | 3.0 | ... | ... | 99.9 | 100.0 | ... | 23.1 | 100.0 | ... | ... | ... | 100.0 | ... | 83.7 | 82.4 | ... | 3.3 | [illegible] | [illegible] | [illegible] |
| Polara | 0.1 | 4.5 | 5.0 | 84.9 | ... | 89.6 | 6.0 | 2.5 | 79.7 | ... | 3.6 | 19.0 | 42.8 | 7.9 | 22.3 | ... | ... | [illegible] | [illegible] | [illegible] |
| Coronet/Charger | 1.7 | 1.0 | ... | 74.3 | ... | 71.7 | 5.3 | 15.7 | 55.4 | ... | 17.9 | ... | 13.8 | ... | ... | ... | ... | [illegible] | [illegible] | [illegible] |
| Challenger | ... | ... | ... | 61.8 | ... | 49.1 | 14.3 | ... | 40.0 | ... | 52.1 | ... | 45.9 | ... | ... | 8.6 | ... | [illegible] | [illegible] | [illegible] |
| Dart | 4.4 | ... | 14.0 | 39.4 | ... | 46.2 | 2.7 | ... | 79.3 | ... | 7.9 | ... | ... | ... | ... | 30.2 | ... | [illegible] | [illegible] | [illegible] |
| Tot. Chrysler Units | 25,542 | 26,239 | 151,871 | 904,272 | 38,545 | 994,267 | 84,193 | 264,293 | 785,195 | 11,237 | 134,432 | 111,408 | 327,783 | 69,208 | 147,076 | 9.5 | 595 | [illegible] | 1,154,[illegible] | 1,[illegible] |
| % Tot. Output | 1.6 | 1.7 | 9.6 | 62.7 | 2.4 | 62.7 | 5.3 | 16.7 | 47.5 | 0.7 | 8.5 | 7.1 | 20.7 | 4.4 | 9.3 | 70,513<br>4.5 | 0.0 | 262,[illegible]<br>17.0 | 74.7 | [illegible] |
| Marinder | ... | 2.2 | 15.3 | 47.0 | ... | 55.7 | 0.3 | ... | 59.7 | ... | 0.9 | ... | 19.7 | 6.5 | 1.5 | 2.7 | ... | 10.8 | [illegible] | [illegible] |
| Hornet | ... | ... | 5.3 | 49.5 | ... | 48.6 | 4.4 | ... | 50.8 | ... | 14.2 | ... | 17.1 | 0.3 | ... | ... | ... | [illegible] | [illegible] | [illegible] |
| Ambassador | ... | 7.4 | 0.1 | 92.7 | ... | 95.2 | 12.8 | 62.9 | ... | ... | 2.6 | ... | 7.5 | 20.1 | 13.0 | 12.6 | ... | 17.4 | [illegible] | [illegible] |
| Javelin | ... | 4.7 | 17.6 | 43.7 | ... | 52.0 | 17.0 | ... | 47.8 | 18.2 | 22.0 | ... | 46.1 | 13.0 | ... | 20.1 | ... | 17.4 | [illegible] | [illegible] |
| Gremlin | ... | ... | 6.0 | 35.0 | ... | 47.5 | 2.7 | ... | 23.9 | ... | 41.4 | ... | ... | 0.6 | ... | ... | ... | [illegible] | [illegible] | [illegible] |
| Tot. AMC Units | ... | 6,256 | 26,231 | 166,027 | ... | 180,162 | 23,052 | 40,695 | 117,663 | 5,707 | 50,365 | ... | 62,[illegible]16 | 20,[illegible]29 | 7,[illegible]21 | 16,612 | ... | 25,[illegible]44 | 106,[illegible]12 | 220,[illegible]23 |
| % Tot. Output | ... | 2.0 | 7.8 | 51.2 | ... | 56.1 | 7.2 | 12.7 | 36.6 | 1.6 | 15.2 | ... | 21.5 | 6.1 | 2.0 | 4.5 | ... | 7.9 | 33.4 | [illegible] |
| TOT. IND. UNITS | 115,077 | 1,366,563 | 550,077 | 7,542,147 | 746,040 | 6,659,331 | 515,029 | 2,562,251 | 4,819,931 | 144,505 | 1,269,153 | 2,592,422 | 1,621,653 | 1,934,420 | 1,076,[illegible]10 | 226,[illegible]03 | 189,531 | 1,636,[illegible]56 | 6,[illegible]884 | 10,[illegible]128 |
| % Tot. Output | 1.1 | 13.3 | 5.4 | 73.5 | 7.3 | 65.3 | 5.9 | 25.0 | 47.0 | 1.1 | 13.6 | 25.2 | 15.8 | 18.4 | 10.4 | 8.6 | 1.9 | 15.6 | 58.6 | [illegible] |

Note: GM, Ford, and Chrysler production figures include units built in Canada for U.S. sale. Pinto and Vega engines are 100% four cylinder. Torino V-8 engine figure includes optional 351-cu. in. engine. Steel-Belted Radial Ply Tires includes some fiberglass. Stereo-Radio-Tape. Rear Window Defogger includes electrically heated rear window on some models. Percent installation rates for Reclining Front Seats are as follows: Chevrolet 4.1; Vega 17.6; Corvette 2.6; Ford 10.7 (Maverick 25.8, Thunderbird 51.2; Mercury 21.3; Comet 24.4; Lincoln 43.0; Mark IV 59.3; Fury 3.6; Chrysler 26.4; Imperial 96.5; Polara 10.4; Monaco 21.4; Hornet 27.5; Ambassador 61.5; Javelin-Torino 9.8; AMX 9.4).

[illegible] [Ct X 6, p 14]

E-1360

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# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '74 MODEL CARS — (Continued)

(MODEL YEAR THROUGH MARCH 31, 1974)

| | Sun Roofs | Steel Belted Radial Ply Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited-Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Adjustable Steering Col. | Speed Reg. Device | Dual Exhausts | Skid Control Device | Rear Window Defogger | Remote Control Sideview Mirror | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | ... | 11.2 | 3.2 | 90.7 | 2.9 | 90.5 | 3.5 | 29.9 | 57.2 | ... | | 31.9 | 14.6 | 29.0 | 13.3 | 4.9 | ... | 32.5 | 24.5 | 41.8 |
| Corvette | ... | 100.0 | | 100.0 | | 79.5 | 96.9 | 100.0 | | ... | | 100.0 | | 73.0 | ... | 100.0 | ... | 17.4 | | |
| Chevelle | 0.3 | 0.2 | 69.4 | 24.1 | 6.5 | 72.7 | 3.0 | 10.9 | 89.3 | ... | 5.1 | | 22.4 | 12.5 | ... | 1.1 | ... | 12.3 | 9.6 | 7.9 |
| Nova | | 2.5 | 2.6 | 54.9 | | 33.6 | 2.5 | | 71.5 | ... | 18.4 | | 6.6 | 1.3 | | 4.4 | ... | 23.5 | | |
| Monte Carlo | 2.3 | 100.0 | 3.4 | 96.3 | | 96.1 | 4.2 | 25.8 | 10.6 | 31.3 | 29.3 | 100.0 | | 45.6 | 14.2 | 4.1 | ... | 2.4 | | |
| Camaro | ... | 35.5 | 2.1 | 81.7 | | 58.5 | 15.2 | | 19.9 | 37.1 | 41.5 | 37.1 | 21.5 | 17.1 | ... | 26.2 | ... | 17.9 | | |
| Vega 2300 | ... | 6.4 | 0.8 | 58.3 | | 38.0 | 5.2 | | 70.9 | ... | 22.1 | | 33.5 | | | | ... | 12.0 | | |
| Pontiac | ... | 39.7 | 8.2 | 83.3 | 6.3 | 88.1 | 5.7 | 18.4 | 55.0 | ... | 22.6 | | 25.2 | 24.5 | 20.5 | 8.1 | ... | 20.3 | | |
| Monte Carlo | 2.3 | 100.0 | 3.4 | 94.3 | | 96.1 | 7.7 | 8.0 | 5.5 | ... | 86.5 | 100.0 | | 63.4 | 28.8 | 100.0 | ... | 15.9 | | |
| LeMans | 1.4 | 25.3 | 17.5 | 71.9 | 1.1 | 79.6 | 4.7 | 9.1 | 35.9 | ... | 48.1 | | 23.8 | 16.4 | 5.5 | 14.2 | ... | 55.0 | | |
| Firebird | ... | 51.3 | 15.2 | 69.5 | | 65.3 | 20.7 | 7.3 | 11.3 | 7.9 | 66.6 | 12.6 | 40.3 | 20.3 | | 33.2 | ... | 87.1 | | |
| Ventura | ... | 7.2 | 22.9 | 33.0 | | 32.5 | 3.6 | | 43.4 | ... | 25.0 | 13.0 | 8.9 | 2.1 | | 11.5 | ... | 14.2 | | |
| Oldsmobile | ... | 20.3 | ... | 97.0 | 59.1 | 36.4 | 5.9 | 81.2 | 18.8 | ... | | 37.9 | 32.7 | 54.6 | 27.6 | 7.1 | ... | 42.1 | | |
| Toronado | 1.2 | 41.9 | ... | 99.3 | 81.1 | 18.6 | | 100.0 | | ... | | 100.0 | | 91.3 | 75.0 | 100.0 | 3.3 | 68.4 | | |
| Cutlass | 4.8 | 22.1 | ... | 92.4 | | 83.0 | 3.8 | | 57.4 | ... | 36.3 | | 25.0 | 22.2 | 5.5 | 6.2 | ... | 14.3 | | |
| Omega | | 4.6 | ... | 43.9 | | 34.6 | 1.7 | | 62.1 | ... | 18.9 | | 5.0 | 3.8 | | | 2.3 | 53.4 | | |
| Delta | 0.4 | 34.1 | 5.9 | 91.5 | 13.3 | 81.9 | 7.2 | 60.3 | 23.9 | ... | 10.8 | 41.2 | 28.7 | 57.2 | 38.3 | 13.1 | 6.5 | 97.3 | | |
| Buick | 4.9 | 65.5 | 1.6 | 97.2 | 26.6 | 72.9 | 19.1 | 29.1 | 9.0 | ... | 61.9 | 100.0 | | 100.0 | 59.7 | 100.0 | | 23.1 | | |
| Riviera | 0.9 | 15.1 | 14.2 | 78.1 | 1.4 | 84.7 | 4.4 | 13.9 | 51.5 | ... | 30.1 | | 35.8 | 36.2 | 6.6 | 4.4 | ... | 16.9 | | |
| Century | | 5.8 | ... | 71.3 | | 51.0 | 2.1 | | 74.2 | ... | 12.0 | | 23.2 | 3.5 | | | 2.8 | 42.1 | | |
| Apollo | | | ... | 99.8 | 99.9 | | 8.1 | 89.1 | 10.9 | ... | | 100.0 | | 27.9 | 49.4 | ... | 6.2 | 88.6 | | |
| Cadillac | 1.9 | 57.0 | ... | 99.8 | 99.9 | | | 100.0 | | ... | | 100.0 | | 89.9 | 67.1 | ... | | | | |
| Eldorado | 10.9 | 71.3 | ... | 99.8 | 99.9 | | | | | ... | | | | | | | | | | |
| Ford | 0.2 | 69.3 | 3.9 | 65.9 | 5.3 | 85.6 | 3.6 | 18.1 | 68.8 | ... | 2.5 | 65.3 | 4.2 | 12.3 | 12.8 | 2.6 | ... | 19.3 | | |
| Torino | 0.5 | 53.7 | 7.5 | 73.6 | 1.9 | 81.4 | 3.0 | 29.6 | 54.1 | ... | 2.4 | 33.4 | 6.7 | 5.3 | 4.1 | | ... | 15.8 | | |
| Maverick | | 25.9 | ... | 54.4 | | 49.3 | | 8.7 | 58.4 | ... | 9.7 | 23.8 | 7.4 | | | 46.1 | ... | 12.3 | | |
| Mustang II | 4.1 | 66.9 | ... | 49.4 | 55.1 | 39.8 | 2.5 | 60.9 | | 29.4 | | 100.0 | | 81.6 | 63.0 | 32.1 | 7.4 | 15.2 | | |
| Thunderbird | 10.9 | 100.0 | ... | 100.0 | | 44.9 | 8.1 | 37.0 | 63.0 | ... | 3.9 | | | | | | | 28.1 | | |
| Pinto | 2.2 | 30.4 | | 48.3 | | 31.7 | | | 81.2 | ... | | 55.5 | 25.4 | 46.9 | 46.7 | | 2.6 | 23.1 | | |
| Mercury | 0.5 | 100.0 | 1.1 | 94.9 | 27.9 | 69.3 | 7.1 | 72.8 | 21.6 | ... | 0.9 | | 29.9 | 12.6 | 9.0 | 0.3 | | 37.1 | | |
| Montego | | 28.9 | 9.6 | 75.4 | 5.3 | 80.8 | 2.9 | 29.6 | 62.3 | ... | 25.4 | 100.0 | | 32.6 | 18.0 | 3.4 | | 6.2 | | |
| Cougar | 3.3 | 99.0 | 2.2 | 98.0 | 13.1 | 80.2 | 5.8 | 38.9 | 35.7 | ... | 3.4 | | | | | | | 6.9 | | |
| Comet | | 26.8 | ... | 57.3 | | 52.7 | | 22.6 | 46.9 | ... | | 100.0 | | 85.2 | 82.4 | | 8.9 | 69.9 | | |
| Lincoln | 2.6 | 100.0 | ... | 100.0 | 100.0 | | 12.9 | 71.7 | 28.3 | ... | | 100.0 | | 94.0 | 87.8 | 28.8 | 100.0 | 93.1 | | |
| Mark IV | 15.2 | 100.0 | ... | 100.0 | 100.0 | | 13.1 | 100.0 | | ... | | | | | | | | | | |
| Fury | 0.1 | 10.1 | 8.0 | 83.2 | 1.1 | 87.9 | 5.9 | 4.2 | 72.5 | | 3.4 | 6.2 | 52.4 | 3.7 | 19.7 | | ... | 21.1 | | |
| Satellite | 97.8 | 0.8 | 88.8 | 8.8 | 3.2 | 78.4 | 4.7 | 10.0 | 57.8 | 4.1 | 10.2 | | 6.8 | | 6.1 | 8.3 | ... | 15.3 | | |
| Barracuda | | 3.6 | | 54.3 | | 38.6 | 13.3 | | 27.7 | ... | 62.2 | | 31.8 | | | 14.8 | ... | 15.5 | | |
| Valiant | 1.5 | 2.7 | 17.2 | 34.8 | | 43.2 | 1.8 | 2.9 | 73.0 | ... | 4.9 | | | | | 1.3 | ... | 17.9 | | |
| Chrysler | 0.4 | 43.0 | 1.7 | 96.4 | 15.5 | 80.9 | 7.0 | 84.3 | 9.3 | ... | 6.4 | 9.0 | 64.1 | 23.4 | 46.2 | | ... | 54.7 | | |
| Imperial | 6.5 | 100.0 | | 100.0 | 100.0 | | 21.1 | 100.0 | | ... | | 100.0 | | 84.0 | 89.6 | | ... | 71.6 | | |
| Marcelo | 0.6 | 34.0 | 4.6 | 88.2 | 3.2 | 86.5 | 6.6 | 1.9 | 78.2 | ... | 7.4 | 5.4 | 62.4 | 10.9 | 35.8 | | ... | 33.8 | | |
| Coronet/Charger | 2.2 | 6.8 | | 75.6 | | 73.0 | 4.4 | 15.3 | 57.7 | ... | 16.3 | | 15.2 | | 14.0 | 5.3 | ... | 22.4 | | |
| Challenger | | 2.9 | ... | 62.5 | ... | 51.2 | 9.9 | | 35.1 | ... | 58.1 | | 42.2 | | | 12.5 | ... | 13.9 | | |
| Dart | 2.3 | 3.0 | 12.1 | 43.4 | ... | 47.4 | 1.9 | 3.4 | 78.9 | ... | 5.5 | | | | | 3.8 | ... | 23.3 | | |
| Matador | ... | 13.4 | 18.8 | 45.2 | ... | 56.9 | 4.7 | ... | 61.0 | ... | 16.3 | | 24.6 | 16.3 | 4.5 | 3.7 | | 48.7 | | |
| Mercury | | 8.4 | 5.6 | 46.5 | ... | 42.1 | 3.4 | | 47.9 | ... | 14.9 | | 23.7 | 4.5 | | | | 26.6 | | |
| Ambassador | 100.0 | | 19.8 | 80.2 | ... | | 9.8 | 91.4 | | ... | 3.9 | | 94.3 | 27.2 | 19.1 | 8.4 | | 58.9 | | |
| Javelin | ... | 8.5 | 17.0 | 41.8 | ... | 48.6 | 12.4 | ... | 46.2 | 15.6 | 19.8 | | 43.3 | 11.4 | ... | 14.6 | | 48.1 | | |
| Gremlin | ... | 4.9 | 5.4 | 35.9 | ... | 34.8 | 2.2 | ... | 25.0 | ... | 36.4 | ... | | 0.9 | | | | 9.8 | | |

Note: GM, Ford, and Chrysler production figures shown in the far right hand column include units built in Canada for U.S. sale. Rear Window Defogger includes electrically heated rear window for some models. Remote Control Sideview Mirror includes right-hand remote control mirror installations of 71.1% on Lincoln and 82.0% on Mark IV models.

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E-1361

ISSUED BY
*Ward's Automotive Reports*
DETROIT, MICHIGAN 48226

MAY 27, 1974

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '74 MODEL CARS

(MODEL YEAR THROUGH MARCH 31, 1974)

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4 Wheel Disc | Disc Brakes Manual | Power Door Locks | Power Seats 2-Way Only | Power Seats 4- or 6-Way | Total Power Windows | Bucket Seats | Vinyl Roofs (Non-Convert.) | Cars Built With Specified Option as % of Total Output of: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 100.0 | | 59.7 | 40.3 | ... | 64.7 | 17.1 | 6.6 | 5.3 | 100.0 | ... | 100.0 | | 15.5 | ... | 2.7 | 16.2 | | 43.5 | 417,991 |
| Corvette | 67.1 | 32.9 | 69.9 | 30.1 | | | 46.5 | 52.2 | | 95.8 | ... | 88.4 | 11.6 | | | | 63.8 | | 11 | 6,122 |
| Chevelle | 87.5 | 0.2 | 69.4 | 24.1 | 6.5 | 72.7 | 11.7 | 2.3 | 5.4 | 98.0 | ... | 92.1 | 7.7 | 3.4 | ... | 0.9 | 3.4 | 100.0 | 1.8 | 57.7 | 211,693 |
| Nova | 88.8 | 1.2 | 53.7 | 9.5 | 36.2 | 84.8 | 4.4 | 0.3 | | 86.7 | 35.4 | 29.4 | | | ... | | | 3.8 | 57.7 | 211,693 |
| Monte Carlo | 100.0 | | 51.9 | 48.1 | | 37.4 | 23.1 | 5.7 | 16.7 | 100.0 | ... | 100.0 | | 13.7 | ... | | | 15.6 | 16.6 | 242,421 |
| Camaro | 67.0 | 7.7 | 58.1 | 33.9 | 8.0 | 60.6 | 21.1 | 8.4 | ... | 100.0 | ... | 94.2 | 5.8 | | ... | 3.6 | 23.4 | 27.5 | 22.6 | 330,551 |
| Vega 2300 | 57.0 | 36.0 | | | | 78.7 | 12.1 | | | 15.7 | | | 100.0 | | ... | | | 100.0 | 23.1 | 85,424 |
| Pontiac | 100.0 | ... | 92.8 | 7.2 | ... | 52.9 | 19.7 | 20.7 | 11.2 | 100.0 | ... | 100.0 | ... | 19.6 | ... | 19.7 | 42.2 | 100.0 | 1.5 | 275,109 |
| Grand Prix | 100.0 | ... | 79.0 | 21.0 | ... | 24.6 | 14.7 | 53.5 | 33.2 | 100.0 | ... | 100.0 | ... | 26.6 | ... | 29.5 | 75.6 | 91.8 | 80.2 | 14,765 |
| LeMans | 99.7 | 0.5 | 27.3 | 68.1 | 4.6 | 62.2 | 16.8 | 11.6 | 11.1 | 98.5 | ... | 92.6 | 7.4 | 5.7 | ... | 4.2 | 11.7 | 37.2 | 55.5 | 102,337 |
| Firebird | 88.5 | 5.7 | 44.5 | 46.7 | 8.8 | 51.6 | 20.4 | 17.6 | 18.1 | 100.0 | ... | 93.6 | 6.4 | 6.2 | ... | | 15.5 | 100.0 | 22.6 | 10,522 |
| Ventura | 85.1 | 2.4 | | 64.6 | 35.4 | 61.5 | 5.5 | 1.3 | ... | 66.5 | 14.9 | 20.6 | | | ... | | | 16.1 | 9.3 | 40,595 |
| Oldsmobile | 100.0 | ... | 100.0 | ... | ... | 43.0 | 10.4 | 43.7 | 13.9 | 100.0 | ... | 100.0 | ... | 45.1 | 0.6 | 47.2 | 55.1 | | 71.9 | 61,453 |
| Toronado | 100.0 | ... | 100.0 | | | 10.9 | 2.7 | 84.9 | 30.8 | 100.0 | ... | 100.0 | ... | 88.2 | ... | 96.3 | 98.1 | | 94.4 | 16,150 |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | 62.5 | 12.4 | 18.9 | 12.4 | 100.0 | ... | 98.4 | 1.6 | 8.0 | ... | 5.0 | 13.5 | 36.4 | 62.0 | 243,419 |
| Omega | 92.1 | ... | | | | 84.0 | 4.2 | 1.6 | | 89.4 | 20.2 | 32.1 | | | | | | 14.2 | 12.0 | 27,104 |
| Buick | 100.0 | ... | 64.2 | 35.8 | 40.7 | 33.2 | 17.5 | 27.8 | 19.5 | 100.0 | ... | 100.0 | ... | 43.4 | 0.7 | 50.9 | 64.0 | | 66.5 | 171,038 |
| Riviera | 100.0 | ... | 90.8 | 9.2 | ... | 6.5 | 6.9 | 43.6 | 42.0 | 100.0 | ... | 100.0 | ... | 70.2 | ... | 89.5 | 97.7 | | 78.7 | 15,942 |
| Century | 100.0 | ... | 62.4 | 37.8 | | 56.6 | 18.9 | 10.7 | 10.0 | 100.0 | ... | 97.3 | 2.7 | 8.6 | ... | 8.0 | 15.1 | 6.0 | 52.9 | 142,873 |
| Apollo | 95.5 | ... | | 76.5 | 23.5 | 81.3 | 9.1 | 1.6 | | 93.9 | 33.5 | 35.8 | | | | | | 7.9 | 33.4 | 42,788 |
| Cadillac | 100.0 | ... | 100.0 | ... | ... | ... | 14.3 | 40.2 | 45.3 | 100.0 | ... | 100.0 | ... | 91.2 | 2.3 | 97.1 | 100.0 | | 94.3 | 132,458 |
| Eldorado | 100.0 | ... | 100.0 | ... | ... | ... | 3.3 | 27.0 | 69.6 | 100.0 | ... | 100.0 | ... | 97.6 | 0.6 | 99.4 | 100.0 | | 95.8 | 31,488 |
| Ford | 100.0 | ... | 100.0 | ... | ... | 74.0 | ... | 19.8 | 3.9 | 100.0 | ... | 100.0 | | 10.5 | ... | 10.4 | 31.5 | | 57.1 | 223,127 |
| Torino | 100.0 | ... | 100.0 | | | 78.2 | ... | 11.7 | 2.0 | 86.8 | ... | 92.2 | 7.8 | 3.3 | ... | 2.0 | 15.3 | | 56.5 | 224,083 |
| Maverick | 90.5 | ... | | 22.2 | 77.8 | 83.5 | 1.7 | 3.5 | | | ... | | 30.8 | | ... | | | 2.6 | 32.5 | 137,915 |
| Mustang II | 69.6 | 30.4 | | | 46.1 | 72.1 | 4.4 | 7.6 | 2.6 | 56.9 | ... | 40.6 | 59.4 | | ... | | | 21.9 | 100.0 | 48,189 |
| Thunderbird | 100.0 | | 100.0 | | | 4.7 | | 30.1 | 32.6 | 100.0 | ... | 100.0 | | 73.6 | ... | 90.9 | 100.0 | 100.0 | 100.0 | 26,429 |
| Pinto | 58.1 | 41.9 | | | | 78.6 | 3.6 | 3.1 | | | ... | | 100.0 | | ... | | | 100.0 | 100.0 | 264,079 |
| Mercury | 100.0 | ... | 88.8 | 11.2 | | 39.4 | ... | 39.8 | 17.4 | 100.0 | ... | 100.0 | | 39.7 | ... | 52.6 | 75.5 | | 78.7 | 17,729 |
| Montego | 100.0 | ... | 100.0 | | | 70.5 | ... | 19.5 | 3.9 | 99.8 | ... | 84.6 | 15.4 | 6.9 | ... | 5.5 | 17.6 | | 69.0 | 67,349 |
| Cougar | 100.0 | ... | 100.0 | | | 35.0 | | 41.2 | 16.8 | 100.0 | ... | 100.0 | | 13.4 | ... | 19.2 | 24.2 | 41.2 | 10 | 61,515 |
| Comet | 90.7 | | | 24.9 | 75.1 | 80.9 | 2.9 | 7.8 | | 85.2 | | | 31.2 | | | | | 28.0 | | 53,152 |
| Lincoln | 100.0 | ... | 100.0 | ... | ... | 4.0 | ... | 56.1 | 39.9 | 100.0 | ... | 100.0 | | 95.5 | ... | 100.0 | 100.0 | | 93.2 | 31,179 |
| Mark IV | 100.0 | ... | 100.0 | ... | ... | ... | ... | 40.3 | 59.7 | 100.0 | ... | 100.0 | ... | 97.0 | ... | 100.0 | 100.0 | | 100.0 | 40,529 |
| Fury | 100.0 | ... | 53.1 | 46.9 | ... | 71.3 | 14.2 | 8.7 | 2.5 | 100.0 | ... | 100.0 | | 6.5 | ... | 6.3 | 22.9 | | 54.0 | 85,861 |
| Satellite | 97.8 | 0.8 | 88.0 | 8.8 | 3.2 | 78.4 | 8.4 | 6.1 | ... | 94.3 | ... | 84.7 | 15.3 | ... | ... | ... | 10.2 | 17.8 | 58.9 | 92,677 |
| Barracuda | 85.0 | 4.9 | 85.2 | 14.8 | | 75.1 | | 21.8 | ... | 92.0 | ... | 46.5 | 53.5 | | ... | | | 100.0 | 51.5 | 9,924 |
| Valiant | 87.3 | 0.4 | 25.0 | | 75.0 | 83.3 | 5.9 | | | 83.9 | ... | 24.7 | 26.3 | | ... | | | 6.2 | 6.0 | 225,908 |
| Chrysler | 100.0 | ... | 93.8 | 6.2 | ... | 45.0 | 15.9 | 33.3 | 10.4 | 100.0 | ... | 100.0 | | 25.7 | ... | 44.5 | 54.5 | | 72.7 | 58,313 |
| Imperial | 100.0 | ... | 100.0 | | | | 7.2 | 92.7 | 52.8 | 100.0 | ... | 100.0 | ... | 89.9 | ... | 97.3 | 100.0 | | 100.0 | 16,055 |
| Monaco | 100.0 | ... | 45.9 | 54.1 | ... | 57.6 | 19.4 | 16.5 | 5.4 | 100.0 | ... | 100.0 | | 18.3 | ... | 19.7 | 32.8 | | 67.5 | 45,558 |
| Coronet, Charger | 93.8 | 0.4 | 81.1 | 14.5 | 4.4 | 71.2 | 11.7 | 10.9 | ... | 97.3 | ... | 87.5 | 12.5 | ... | ... | ... | 17.3 | 21.3 | 72.5 | 84,720 |
| Challenger | 90.5 | 2.7 | 87.5 | 12.5 | | 74.4 | | 22.2 | ... | 94.3 | ... | 86.6 | 13.4 | ... | ... | ... | | 100.0 | 76.3 | 12,997 |
| Dart | 94.3 | 0.4 | 31.2 | | 68.8 | 88.1 | 6.2 | ... | ... | 87.2 | ... | 32.5 | 26.7 | ... | ... | ... | | 5.8 | 74.2 | 171,268 |
| Matador | 98.0 | ... | 7.5 | 67.2 | 25.3 | 74.2 | ... | 12.0 | 2.1 | 95.3 | ... | 55.4 | 27.8 | ... | ... | ... | 5.9 | 15.1 | 44.2 | 56,583 |
| Hornet | 87.9 | ... | | 11.8 | 87.8 | 66.5 | ... | 7.6 | ... | 72.2 | 8.8 | 10.1 | 8.9 | ... | ... | ... | | 12.0 | 8.4 | 83,103 |
| Ambassador | 100.0 | ... | 19.8 | 80.2 | | 74.9 | ... | 18.6 | 2.0 | 100.0 | ... | 100.0 | | ... | ... | ... | 32.6 | | 43.8 | 22,054 |
| Javelin | 85.3 | 3.8 | 4.7 | 76.4 | 18.9 | 66.7 | ... | 16.3 | 8.3 | 99.2 | | 51.2 | 47.9 | ... | ... | ... | | 100.0 | 42.9 | 19,778 |
| Gremlin | 71.3 | ... | | 9.8 | 90.2 | 64.2 | ... | 7.1 | ... | 47.2 | 5.6 | 2.2 | 6.6 | ... | ... | ... | | 46.4 | | 27,260 |

Note: GM, Ford, and Chrysler production figures shown in the far right hand column include units built in Canada for U.S. sale. Pinto and Vega engines are 100% 4-cylinder. Ford Motor Co. V-8 Engine Standard includes optional V-8s on some Lines where insufficient data was supplied to give an accurate breakdown. Percent installation rates for Reclining Front Seats are as follows: Chevrolet, 1.3; Ford, 15.0; Maverick, 17.9; Thunderbird, 62.9; Mercury, 26.1; Comet, 22.6; Lincoln, 53.1; Mark IV, 59.2; Fury, 2.7; Chrysler, 46.0; Imperial, 73.1; Monaco, 26.2; Matador, 37.6; Hornet, 31.8; and Ambassador, 72.5. Stereo Tape Players include in some instances Stereo Radio Tapes.

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P

[Ct X 6, p 18]

| Mfr. | Model Year | 1969 Total Production | 1969 Anti-Skid (Number) | 1969 Anti-Skid (Percent) | 1970 Total Production | 1970 Anti-Skid (Number) | 1970 Anti-Skid (Percent) | 1971 Total Production | 1971 Anti-Skid (Number) | 1971 Anti-Skid (Percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ford | Mark III/IV | 22,564 | 1,692 | 7.5% | 21,432 | 21,432 | 100.0% | 27,091 | 27,091 | 100.0% |
| | Thunderbird | 49,272 | 148 | 0.3 | 50,364 | 1,108 | 2.2 | 36,055 | 2,632 | 7.3 |
| | Lincoln | (Anti-Skid Not Offered) | | | 37,695 | 3,732 | 9.9 | 35,551 | 3,021 | 8.5 |
| | Mercury | ( " " " ) | | | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | Other Ford | ( " " " ) | | | ( " " " ) | | | ( " " " ) | | |
| | Total Ford | 2,144,928 | 1,840 | 0.1% | 2,036,211 | 26,272 | 1.3% | 2,141,837 | 32,744 | 1.5% |
| GM | Toronado | (Anti-Skid Not Offered) | | | 25,475 | 459 | 1.8% | 29,265 | 1,931 | 6.6% |
| | Cadillac | ( " " " ) | | | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | El Dorado | ( " " " ) | | | 23,842 | 143 | 0.6 | 27,368 | 1,177 | 4.3 |
| | Other GM | ( " " " ) | | | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | Total GM | 4,415,511 | 0 | 0% | 4,095,419 | 602 | 0.01% | 3,556,263 | 3,108 | 0.1% |
| Chrysler | Imperial | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | | 11,432 | 263 | 2.4% |
| | Other Chrysler | ( " " " ) | | | ( " " " ) | | | (Anti-Skid Not Offered) | | |
| | Total Chrysler | 1,479,459 | 0 | 0.0% | 1,311,073 | 0 | 0% | 1,256,259 | 263 | 0.02% |

E-1364

EXHIBIT "B"

STATE OF NEW YORK
COUNTY OF } ss.:

The undersigned, an attorney admitted to practice in the courts of New York State, certifies that the within has been compared by the undersigned with the original and found to be a true and complete copy.

Dated:

VERIFICATION, CORPORATE OR INDIVIDUAL

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes:

Deponent is the of a corporation, in the within action;

Deponent has read the foregoing and knows the contents thereof; the same is true to deponent's own knowledge, except as to the matters therein alleged upon information and belief, and those matters deponent believes to be true.

The grounds of deponent's belief as to all matters not stated upon deponent's own knowledge are as follows:

Sworn to before me,
this day of 19

AFFIDAVIT OF PERSONAL SERVICE

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes and says, that deponent is not a party to the action, is over 18 years of age and resides
That on the day of 19
at No.
deponent served the within
upon
the herein,
by delivering a true copy thereof to personally.
Deponent knew the person so served to be the person mentioned and described in said papers as the therein.

Sworn to before me,
this day of 19

AFFIDAVIT OF SERVICE BY MAIL

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes and says; that deponent is not a party to the action, is over 18 years of age and resides at
That on the day of 19
deponent served the within
upon
attorney(s) for
in this action, at
the address designated by said attorney(s) for that purpose by depositing a true copy of same enclosed in a postpaid properly addressed wrapper, in — a post office — official depository under the exclusive care and custody of the United States post office department within New York State.

Sworn to before me,
this day of 19

## ATTORNEY'S AFFIRMATION

STATE OF NEW YORK
COUNTY OF ss.:

The undersigned, an attorney admitted to practice in the courts of New York State, hereby affirms as true under all the penalties of perjury that affiant is

the attorney(s) of record for
in the within action; that affiant has read the foregoing
and knows the contents thereof; that the same is true to affiant's own knowledge, except as to the matters therein stated to be alleged on information and belief, and that those matters affiant believes to be true. Affiant further says that the reason this verification is made by deponent and not by

The grounds of affiant's belief as to all matters not stated upon affiant's knowledge are as follows:

Dated 19

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Index No. 66 Civ. 665 Year 19(MID)
UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

PERMA RESEARCH & DEVELOPMENT COMPANY,

Plaintiff,

- against -

THE SINGER COMPANY,

Defendant.

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STIPULATION OF FACTS

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POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for Plaintiff
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N.Y. 10017
(212) 888-3200

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To

Attorney(s) for

Service of a copy of the within

is hereby admitted.

Dated, 19

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NOTICE OF ENTRY

Please take notice that the within is a
copy of a
duly entered in the office of the clerk of the within
named Court on 19

Yours, etc.

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N.Y. 10017

---

NOTICE OF SETTLEMENT

Please take notice that an order
of which the within is a
will be presented for settlement to the
Hon. one of the judges of the within named Court, at
on the day of 19
at M.

Yours, etc.

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N.Y. 10017

[DX 708, p 44]

44

15 mph
15 mm

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.300 | 5.33 | 7.87 | 13.00 | 98.65 | .030 | .030 | .030 | 0.51 | 0.39 | 250.0 | 150.0 | 0.92 | 700. | .344 | 20.0 | | | |
| | 0.000 | 0.0 | 22.00 | 0.00 | 0.0 | 22.00 | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | 0.0 | 22.00 | 0.00 | 0.000 | 22.00 | 0.00 | 0.000 | |
| | 0.050 | 1.1 | 21.79 | 0.23 | 663.6 | 16.13 | -9.41 | 0.260 | 16.13 | -9.41 | 0.260 | 398.2 | 18.76 | -3.64 | 0.139 | 18.76 | -3.64 | 0.139 | |
| | 0.100 | 2.2 | 21.47 | 0.17 | 544.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 470.4 | 8.48 | -7.48 | 0.605 | 8.48 | -7.48 | 0.605 | |
| | 0.150 | 3.2 | 21.21 | 0.16 | 170.4 | 0.20 | 1.56 | 0.991 | 0.20 | 1.56 | 0.991 | 107.0 | 4.96 | 2.30 | 0.766 | 4.65 | 2.30 | 0.766 | |
| | 0.200 | 4.3 | 20.93 | 0.19 | 153.9 | 7.47 | 3.88 | 0.643 | 7.47 | 3.88 | 0.643 | 92.3 | 11.42 | 3.53 | 0.454 | 11.42 | 3.53 | 0.454 | |
| | 0.250 | 5.3 | 20.65 | 0.18 | 206.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 170.6 | 7.43 | 0.64 | 0.640 | 7.43 | 0.64 | 0.640 | |
| | 0.300 | 6.4 | 20.37 | 0.18 | 399.1 | 1.86 | -3.92 | 0.908 | 1.86 | -3.92 | 0.908 | 236.5 | 10.82 | -0.82 | 0.469 | 10.82 | -0.82 | 0.469 | |
| | 0.350 | 7.4 | 20.09 | 0.17 | 265.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 199.5 | 9.03 | 1.14 | 0.551 | 9.03 | 1.14 | 0.551 | |
| | 0.400 | 8.4 | 19.82 | 0.17 | 427.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 256.6 | 9.06 | -1.61 | 0.543 | 9.06 | -1.61 | 0.543 | |
| | 0.450 | 9.4 | 19.54 | 0.18 | 354.6 | 1.66 | -2.56 | 0.915 | 1.66 | -2.56 | 0.915 | 212.8 | 11.49 | 0.06 | 0.412 | 11.49 | 0.06 | 0.412 | |
| | 0.500 | 10.3 | 19.26 | 0.18 | 189.4 | 0.27 | 1.87 | 0.986 | 0.27 | 1.87 | 0.986 | 113.6 | 9.85 | 2.72 | 0.489 | 9.85 | 2.72 | 0.489 | |
| | 0.550 | 11.3 | 18.97 | 0.16 | 293.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 176.1 | 11.10 | 1.19 | 0.415 | 11.10 | 1.19 | 0.415 | |
| | 0.600 | 12.2 | 18.69 | 0.18 | 176.3 | 0.44 | 2.23 | 0.977 | 0.44 | 2.23 | 0.977 | 105.8 | 10.62 | 3.22 | 0.432 | 10.62 | 3.22 | 0.432 | |
| | 0.650 | 13.1 | 18.40 | 0.18 | 451.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 271.0 | 11.12 | -1.36 | 0.395 | 11.12 | -1.36 | 0.395 | |
| | 0.700 | 14.1 | 18.11 | 0.18 | 426.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 255.6 | 11.11 | -0.85 | 0.387 | 11.11 | -0.85 | 0.387 | |
| | 0.750 | 15.0 | 17.83 | 0.18 | 480.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 288.3 | 11.05 | -1.73 | 0.360 | 11.05 | -1.73 | 0.360 | |
| | 0.800 | 15.8 | 17.54 | 0.18 | 495.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 297.3 | 11.01 | -1.96 | 0.372 | 11.01 | -1.96 | 0.372 | |
| | 0.850 | 16.7 | 17.26 | 0.18 | 483.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 290.3 | 11.07 | -1.72 | 0.359 | 11.07 | -1.72 | 0.359 | |
| | 0.900 | 17.6 | 16.99 | 0.18 | 521.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 313.0 | 10.99 | -2.33 | 0.353 | 10.99 | -2.33 | 0.353 | |
| | 0.950 | 18.4 | 16.70 | 0.17 | 463.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 278.0 | 11.08 | -1.36 | 0.336 | 11.08 | -1.36 | 0.336 | |
| | 1.000 | 19.2 | 16.42 | 0.17 | 505.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 303.3 | 11.01 | -2.09 | 0.333 | 11.01 | -2.09 | 0.333 | |
| | 1.050 | 20.1 | 16.14 | 0.17 | 485.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 291.1 | 11.05 | -1.72 | 0.316 | 11.05 | -1.72 | 0.316 | |
| | 1.100 | 20.9 | 15.86 | 0.17 | 516.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 309.8 | 10.97 | -2.26 | 0.308 | 10.97 | -2.26 | 0.308 | |
| | 1.150 | 21.8 | 15.58 | 0.18 | 495.1 | 0.0 | 0. | 1.000 | 0.0 | 0.0 | 1.000 | 297.1 | 11.05 | -1.86 | 0.291 | 11.05 | -1.86 | 0.291 | |
| | 1.200 | 22.4 | 15.30 | 0.18 | 503.5 | 0.0 | 0. | 1.000 | 0.0 | 0.0 | 1.000 | 302.1 | 11.06 | -1.97 | 0.277 | 11.06 | -1.97 | 0.277 | |
| | 1.250 | 23.2 | 15.02 | 0.18 | 492.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 295.2 | 11.10 | -1.72 | 0.261 | 11.10 | -1.72 | 0.261 | |
| | 1.300 | 23.9 | 14.73 | 0.18 | 481.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 288.6 | 11.16 | -1.49 | 0.243 | 11.16 | -1.49 | 0.243 | |
| | 1.350 | 24.6 | 14.45 | 0.18 | 484.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 290.9 | 11.20 | -1.48 | 0.227 | 11.20 | -1.48 | 0.325 | |
| | 1.400 | 25.4 | 14.16 | 0.18 | 410.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 246.4 | 11.30 | -0.13 | 0.201 | 11.30 | -0.13 | 0.201 | |
| | 1.450 | 26.1 | 13.86 | 0.19 | 359.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 215.4 | 11.38 | 0.83 | 0.179 | 11.38 | 0.83 | 0.179 | |
| | 1.500 | 26.7 | 13.57 | 0.18 | 209.9 | 0.09 | 1.14 | 0.993 | 0.09 | 1.14 | 0.993 | 125.9 | 10.65 | 3.29 | 0.215 | 10.65 | 3.29 | 0.215 | |
| | 1.550 | 27.4 | 13.27 | 0.18 | 249.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 149.6 | 10.91 | 2.63 | 0.208 | 10.91 | 2.63 | 0.208 | |
| | 1.600 | 28.1 | 12.97 | 0.18 | 298.6 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 179.2 | 9.87 | 1.69 | 0.239 | 9.87 | 1.69 | 0.239 | |
| | 1.650 | 28.7 | 12.68 | 0.18 | 336.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 202.1 | 10.07 | 1.14 | 0.206 | 10.07 | 1.14 | 0.206 | |
| | 1.700 | 29.3 | 12.38 | 0.19 | 322.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 193.4 | 10.27 | 1.49 | 0.170 | 10.27 | 1.49 | 0.170 | |
| | 1.750 | 29.9 | 12.09 | 0.18 | 263.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 158.1 | 10.63 | 2.28 | 0.120 | 10.63 | 2.28 | 0.120 | |
| | 1.800 | 30.5 | 11.81 | 0.17 | 447.2 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 268.3 | 10.82 | -2.00 | 0.083 | 10.82 | -2.00 | 0.083 | |
| | 1.850 | 31.1 | 11.53 | 0.18 | 456.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 272.6 | 10.16 | -1.03 | 0.118 | 10.16 | -1.03 | 0.118 | |
| | 1.900 | 31.7 | 11.25 | 0.17 | 301.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 180.6 | 10.15 | 1.07 | 0.098 | 10.15 | 1.07 | 0.098 | |
| | 1.950 | 32.3 | 10.99 | 0.15 | 269.8 | 0.04 | 0.75 | 0.996 | 0.04 | -0.75 | 0.996 | 125.9 | 10.35 | 0.86 | 0.056 | 10.35 | 0.86 | 0.056 | |
| | 2.000 | 32.8 | 10.75 | 0.14 | 364.2 | 0.41 | -1.85 | 0.962 | 0.41 | -1.85 | 0.962 | 182.5 | 10.26 | -1.60 | 0.045 | 10.26 | -1.60 | 0.045 | |
| | 2.050 | 33.3 | 10.51 | 0.16 | 392.5 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 235.5 | 9.62 | -0.94 | 0.064 | 9.62 | -0.94 | 0.064 | |
| | 2.100 | 33.8 | 10.27 | 0.15 | 278.4 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 167.0 | 9.56 | 0.31 | 0.059 | 9.56 | 0.31 | 0.059 | |
| | 2.150 | 34.4 | 10.03 | 0.18 | 543.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 326.3 | 8.66 | -2.18 | 0.136 | 8.66 | -2.18 | 0.136 | |
| | 2.200 | 34.8 | 9.76 | 0.14 | 218.4 | 0.83 | 0.77 | 0.915 | 0.83 | 0.77 | 0.915 | 131.0 | 9.38 | -0.45 | 0.039 | 9.38 | -0.45 | 0.039 | |
| | 2.250 | 35.3 | 9.49 | 0.18 | 295.0 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 177.0 | 8.18 | 2.11 | 0.139 | 8.18 | 2.11 | 0.139 | |
| | 2.300 | 35.8 | 9.25 | 0.17 | 465.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 279.6 | 8.30 | -1.53 | 0.102 | 8.30 | -1.53 | 0.102 | |
| | 2.350 | 36.2 | 8.98 | 0.13 | 130.4 | 0.70 | 1.96 | 0.922 | 0.70 | 1.96 | 0.922 | 100.2 | 8.65 | -0.06 | 0.035 | 8.65 | -0.06 | 0.035 | |
| | 2.400 | 36.7 | 8.71 | 0.18 | 358.1 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 214.8 | 7.10 | 0.93 | 0.185 | 7.10 | 0.93 | 0.185 | |
| | 2.450 | 37.1 | 8.46 | 0.17 | 330.4 | 0.54 | -3.99 | 0.936 | 0.54 | -3.99 | 0.936 | 234.2 | 7.79 | -1.14 | 0.060 | 7.79 | -1.14 | 0.060 | |
| | 2.500 | 37.5 | 8.17 | 0.15 | 181.5 | 0.27 | 1.91 | 0.967 | 0.27 | 1.91 | 0.967 | 108.9 | 7.75 | 0.93 | 0.051 | 7.75 | 0.93 | 0.051 | |
| | 2.550 | 37.9 | 7.92 | 0.10 | 534.9 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 320.9 | 6.45 | -2.19 | 0.185 | 6.45 | -2.19 | 0.185 | |
| | 2.600 | 38.3 | 7.65 | 0.15 | 227.2 | 1.64 | 1.50 | 0.785 | 1.64 | 1.50 | 0.785 | 136.3 | 7.34 | -0.55 | 0.041 | 7.34 | -0.55 | 0.041 | |
| | 2.650 | 38.7 | 7.37 | 0.18 | 287.7 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 172.6 | 6.02 | 2.06 | 0.182 | 6.02 | 2.06 | 0.182 | |
| | 2.700 | 39.1 | 7.11 | 0.19 | 420.1 | 1.73 | -3.90 | 0.785 | 1.73 | -3.90 | 0.760 | 252.0 | 6.46 | -1.18 | 0.092 | 6.46 | -1.18 | 0.092 | |
| | 2.750 | 39.4 | 6.82 | 0.14 | 171.7 | 0.41 | 2.38 | 0.939 | 0.41 | 2.38 | 0.939 | 103.0 | 6.51 | 0.89 | 0.045 | 6.51 | 0.89 | 0.045 | |
| | 2.800 | 39.7 | 6.56 | 0.18 | 554.8 | 0.5 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 332.8 | 5.20 | -2.59 | 0.207 | 5.20 | -2.59 | 0.207 | |
| | 2.850 | 40.1 | 6.27 | 0.16 | 175.5 | 1.65 | 3.24 | 0.756 | 1.65 | 3.24 | 0.756 | 105.3 | 6.09 | -0.34 | 0.031 | 6.09 | -0.34 | 0.031 | |
| | 2.900 | 40.4 | 6.03 | 0.18 | 377.3 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 226.4 | 27 | 0.13 | 0.321 | 4.07 | 0.13 | 0.321 | |
| | 2.950 | 40.7 | 5.75 | 0.17 | 454.4 | 2.10 | 0.446 | 1.00 | 2.10 | 0.446 | 1.00 | 152.4 | .48 | -0.63 | 0.047 | 5.48 | -0.63 | 0.047 | |
| | 3.000 | 41.0 | 5.53 | 0.18 | 378.8 | 0.0 | 0.0 | 1.000 | 0.0 | 0.0 | 1.000 | 167.9 | 3.89 | 1.91 | 0.796 | 3.89 | | | |

[DX 708, p 44]

E-1297

EXHIBIT 7
4/11/64

DANT'S EXHIBIT 13 FOR IDENTIFICATION (PAGES 1-4)

E. I. DU PONT DE NEMOURS & COMPANY
WILMINGTON 98, DELAWARE

CC: C. R. Bigelow
R. C. 13

ENGINEERING DEPARTMENT

RECEIVED
APR 11 1964
FACTORY SALES

April 9, 1964

E. T. [illegible]RDEN
PLAST[illegible] DEPARTMENT
WILMINGTON

ENGINEERING APPRAISAL OF "PERMA" ANTI-SKID DEVICE

As you requested on April 2, 1964, we have made a cursory review of the adequacy, utility, and reliability of the subject device. Since we have not had the opportunity to test a unit in actual use on a car, or under controlled conditions in a laboratory, we can only furnish an engineering opinion. It is our understanding that this investigation was deemed advisable as a result of a recent service failure in Detroit and because of the ramifications of a proposed advertising campaign.

The prevention of skidding, with attendant loss of steering control, is certainly a worthwhile objective. Skidding, however, can result from several circumstances, of which only one involves "panic" braking. The attached copy of an article from the March, 1964 edition of "Popular Science" Magazine describes more fully some of the recent research on causes of skids.

In addition to braking, skidding can also be caused by excessive speed, dangerous road conditions, and excessive acceleration. Since the "Perma" anti-skid system is only effective on skids associated with braking, it seems to us that it would be necessary to clearly inform the customer of this limitation to avoid lulling him into a false sense of security that could make him dangerously vulnerable to skids resulting from non-braking situations.

Based on published information and the experience of people of your own Department, there is no doubt about the effectiveness of the anti-skid device in controlling braking skids. It should be remembered, however, that the unit is not intended to shorten stopping distance, but only to provide steering control during hard braking.

D.P.C. 13

BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

2
April 9, 1964
E. T. Darden

This limited evaluation is based on the technical literature furnished, a visual examination of the unit, and a telephone conversation with Frank Perrino, the inventor.

It appears that the design change made as a result of the Detroit incident will be effective in preventing this kind of failure. There are, however, a number of other types of possible failures that could occur.

Please keep in mind that we are not predicting these failures or attempting to define the probability, since this cannot be done without adequate test data.

Inherently, the basic design concept is not fail-safe since experience, as well as logic, shows that failure of the anti-skid device can result in the total loss of braking. Some of the types of possible failure that could result in loss of braking are:

1. Plugging of air filter No. 65 could result in the inability of the unit to cycle with partial or total loss of braking.
2. Failure of the solenoid spring No. 46 could prevent the unit from cycling with resultant loss of braking.
3. Displacement of the governor spring No. 47 into the clearance between the ends of the governor shaft and shaft No. 48 could result in loss of braking.
4. Welding of the contacts of pressure switch No. 38 could result in the inability of the unit to cycle with loss of braking.
5. Failure of the pressure switch spring No. 41 could similarly result in loss of braking.
6. Failure of the accumulator piston seals could result in loss of hydraulic fluid and braking failure.
7. Jamming of the pressure switch piston No. 39 while the switch is in the "closed" position could also result in failure to cycle with loss of braking.

In addition to these failures, there are four general component design categories involved in this device which would normally be the focus of a considerable amount of testing.

E-1299

[DX 13 for id, p 2]



3
April 9, 1964
E. T. Darden

These are:

1. Gears and shafts - This marginally-lubricated drive train is particularly susceptible to failure under the conditions of operation. The governor shaft rotates at approximately 5000 rpm at 25 mph and at nearly 15,000 rpm at 75 mph (these figures were obtained from Perrino).
2. Switches - Switches operating in direct current circuits such as these can be a source of trouble.
3. Coil - The solenoid coil should be tested to determine reliability and longevity.
4. Plugged fluid passages - In addition to the air filter mentioned before, plugging could occur in the hydraulic system in the check valve and pressure switch which are introduced into the hydraulic brake line.

Our over-all impression is that the device represents an ingenious design, has been carefully developed, and is undoubtedly effective in controlling braking skids; but complexity and multiplicity of components make it vulnerable to sudden service failures with possible disastrous consequences. I would like to point out again that the probability of failure cannot be predicted without adequate tests.

Mr. Perrino has apparently made a considerable number of tests of the anti-skid unit, but certain important tests still need to be made. For example, cyclic functional sequencing tests to determine both system and component reliability have not been made. In a mechanical device like this where danger to life is involved, reliability should be established in the laboratory rather than in-service. In view of this, I would like to suggest that we make a more thorough investigation, including tests at the Engineering Test Center, before the proposed advertising is released.

Please advise if you would like us to prepare an estimate of this comprehensive engineering evaluation.

ENGINEERING SERVICE DIVISION
Packaging and Product Engineering Group

A. F. Barker

AFB:daf

[DX 13 for id, p 3]

E-1300

[DX 13 for id, p 4]

...or W. Wigotsky, Eastern Editor

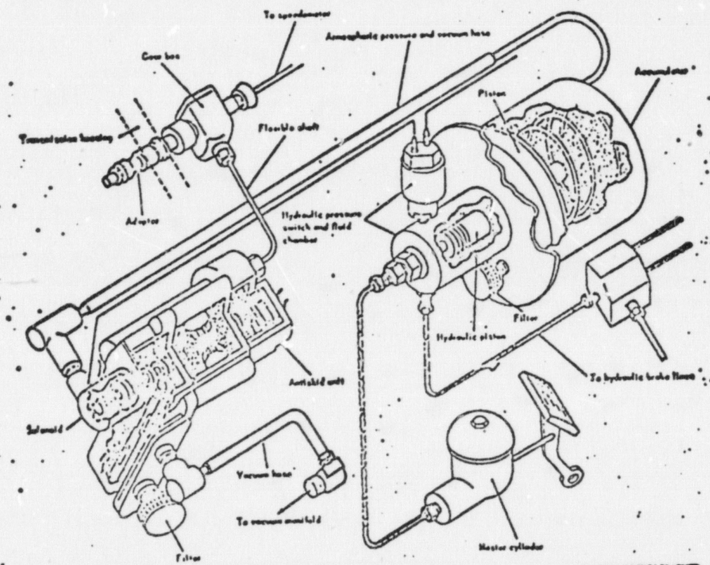
A simplified antiskid device uses engine vacuum to control a variable accumulator for release of braking pressure in event of wheel lock-up. The redesigned unit, quickly installed on cars with or without power brakes, is a self-contained accessory that modulates brake-line pressure to a point just below the skid-producing pressure.

The original unit (DESIGN NEWS, April 11, 1960) provided combined automatic braking and skid control through the accelerator pedal. A later design was built around a power brake. Engine vacuum in both cases modulated brake pressure as regulated by a rotary valve. The latter effected release of skid pressure through a governor that responded to wheel lock-up. A safety valve allowed brake fluid to bypass the power brake and provide adequate pressure in event of engine failure or stall. In addition, damping was provided for the driver who wanted to avoid the sensitive feeling of the power brakes.

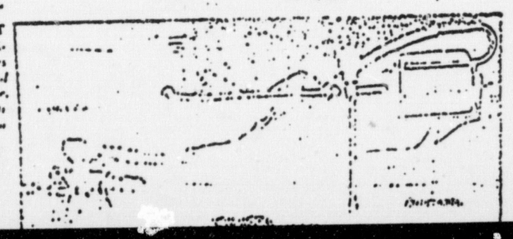
The redesign is independent of a specific braking arrangement and functions as an easily installed accessory. The antiskid unit is the same, except that now it simply regulates a separate variable accumulator, only in event of a skid condition. Engine vacuum releases the brake-line pressure to just below the skid level when a wheel lock-up condition occurs. Vacuum is fed to the release side of the accumulator through the rotation of the rotary valve in the antiskid unit. At the same time, closing of a valve in the hydraulic section of the accumulator prevents overriding of the antiskid system by the driver.

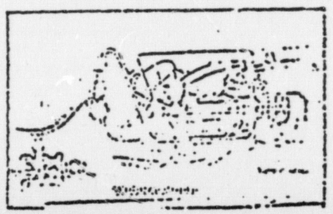
There is no change in the "feel" of the brake pedal after the unit is installed. Also, since the device does not rely on vacuum for braking power, there is no need for the safety valve and associated lines and fittings.

The redesigned antiskid control is a product of Perma Research and Development Co., North Attleboro, Mass.




**SELF-CONTAINED UNIT** *supplements existing braking system, Governor senses locked wheel condition and modulates rotary valve. Solenoid assures that antiskid system will be operative only during skid*





**UNIT WITH POWER BRAKE** *required replacement of existing brake system and complicated assembly*

[DX 335 for id, p 1]

DEFENDANT'S EXHIBIT 335 FOR IDENTIFICATION

Messrs. S. Boriss
C. W. Brecker
R. H. Zinna

cc: Mr. A. Rozel

B. C. Person

February 15, 1966

VISIT TO KELSEY-HAYES

The purpose of this memorandum is to pass along some of the highlights of the discussion Mr. Rozel and I had with Kelsey-Hayes during our visit of February 3.

The summary and conclusion of their test of the Perma Anti-Skid unit is included as Exhibit III in the material we presented to Mr. Kircher, of which each of you should have a copy.

Their highlights are as follows:

1. Our conversation confirmed the design criteria we have been using for minimum pressures - 1,000 P.S.I. Their engineer indicated that the minimum should be increased at least 200 P.S.I. for disc brakes. (From his experience, Mr. Rozel believes the minimum would have to be increased further.)

2. Kelsey-Hayes engineers indicated they felt vacuum was not a good source of power for an anti-skid device because it limits the cycles per second. From experimental work that they have done, they indicated the following practical cycle rates:

   Vacuum - about 5 cycles per second

   Compressed Air - about 25 cycles per second

   Hydraulic Pressure - about 350-400 cycles per second

   While they had not instrumented the car, they estimated the anti-skid unit was cycling somewhere between 3-5 cycles per second, which is too slow a frequency of 10 cycles per second would be more successful.

3. The optimum stopping rate is 27' per second, per second. Some cars equipped with Kelsey-Hayes brakes are already approaching this optimum.

4. Kelsey-Hayes believes the cost target for an anti-skid unit would be $30-40 at the retail level, which means $9-$10 factory cost.

Original signed by
B. C. Person

BCP:ER

DX 335

After viewing all available copies of the preceding page, counsel for Appellant believes that said page reads as follows:

Messrs. B. Boriss
C.W. Brecker
R.H. Zimann

cc: Mr. A. Romel

B.C. Person

February 15, 1966

VISIT TO KELSEY-HAYES

The purpose of this memorandum is to pass along some of the highlights of the discussion Mr. Romel and I had with Kelsey-Hayes during our visit of February 3.

The summary and conclusion of their test of the Perma Anti-Skid unit is included as Exhibit III in the material we presented to Mr. Kircher, of which each of you should have a copy.

Their highlights are as follows:

1. Our conversation confirmed the design criteria we have been using for minimum pressures - 1,000 P.S.I. Their engineer indicated that the minimum should be increased at least 200 P.S.I. for disc brakes. (From his experience, Mr. Romel believes the minimum would have to be increased further.)

2. Kelsey-Hayes engineers indicated they felt vacuum was not a good source of power for an anti-skid device because it limits the cycles per second. From experimental work that they have done, they indicated the following practical cycle rates:

   Vacuum - about 5 cycles per second

   Compressed Air - about 25 cycles per second

   Hydraulic Pressure - about 300-400 cycles per second

   While they had not instrumented the car, they estimated the anti-skid unit was cycling somewhere between 3-5 cycles per second, which is too slow; a frequency of 10 cycles per second would be more successful.

3. The optimum stopping rate is 27' per second, per second. Some cars equipped with Kelsey-Hayes brakes are already approaching this optimum.

4. Kelsey-Hayes believes the cost target for an anti-skid unit would be $30-40 at the retail level, which means $0-$10 factory cost.

Original signed by

B.C.Person





KELSEY-HAYES COMPANY
INTER DEPARTMENT CORRESPONDENCE



February 3, 1966

To: H. Hayes

From: D. Every

Subject: Evaluation of the Perma Anti-Skid System

Object: The object of this evaluation was to determine whether the Perma-Anti-Skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Perma-Anti-Skid System was loaned to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the brake manifold connection was through a 1/2" diameter bore hose, the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance a directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult to maintain and on many of the 60 m.p.h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

The major objection to the system is that the rear wheels are required to lock completely before the brake pressure is reduced which is the primary cause for the instability and jerkiness.

The test have not indicated that the System or any of its components offer any promise for development in a Kelsey-Hayes System. It must be pointed out here that no instrumentation was used on the system thus the possibility of any system modifications to improve performance cannot be determined accurately.

Test Procedure:

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration, stopping distance and vehicle stability.

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.

335

(transcribed on page E-1303A)

After viewing all available copies of the preceding page, councel for Appellant believes that said page reads as follows:

"February 3, 1966

To: M. Meyer

From: (P?)(Every?)

Subject: Evaluation of the Perma Anti-Skid System

Object: The object of this evaluation was to determine whether the Perma Anti-Skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Perma Anti-Skid System was (loaned?) to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the intake manifold connection was through a (?/?)" diameter ?..., the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance and directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult to maintain and on many of the 60 m.p h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

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Test Procedure:

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration stopping distance and vehicle stability.

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.



KELSEY-HAYES COMPANY
INTER DEPARTMENT CORRESPONDENCE



February 3, 1966

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum tank and check valve between the manifold and system.

Test Results:

All the 30 m.p.h. stops were stable with little or no steering correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

The average stopping distance on wet pavement was the same for four wheel or rear only pumping, and without the system.

The majority of the 60 m.p.h. stops required considerable steering correction to keep the car on the road and on several occasions the brake pedal had to be released. The car was generally more easily controlled without the system operating. The few straight stops were achieved when the front wheels locked during the first part of the stop. The stopping distances with the system operating were generally equal to or greater than without the system on wet pavement.

Several occasions one rear wheel locked for 30 feet or more before the other, under these conditions the system cannot pump. Generally the car slide a considerable distance before the pumping action could be detected except for the test made in configuration 6, when the system started pumping immediately after the rear wheel locked, however, straight stops could only be achieved by limiting the applied pressure.

The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Dimola.

Conclusions:

On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

P. Every

P.Every/sak



(transcribed on page E-1304A)

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum (tank?) and check valve between the manifold and system.

**Test Results:**

All the (30?) m.p.h. stops were (stable?) with little or no steering correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

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The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Lincoln.

**Conclusions:**

On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceeded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

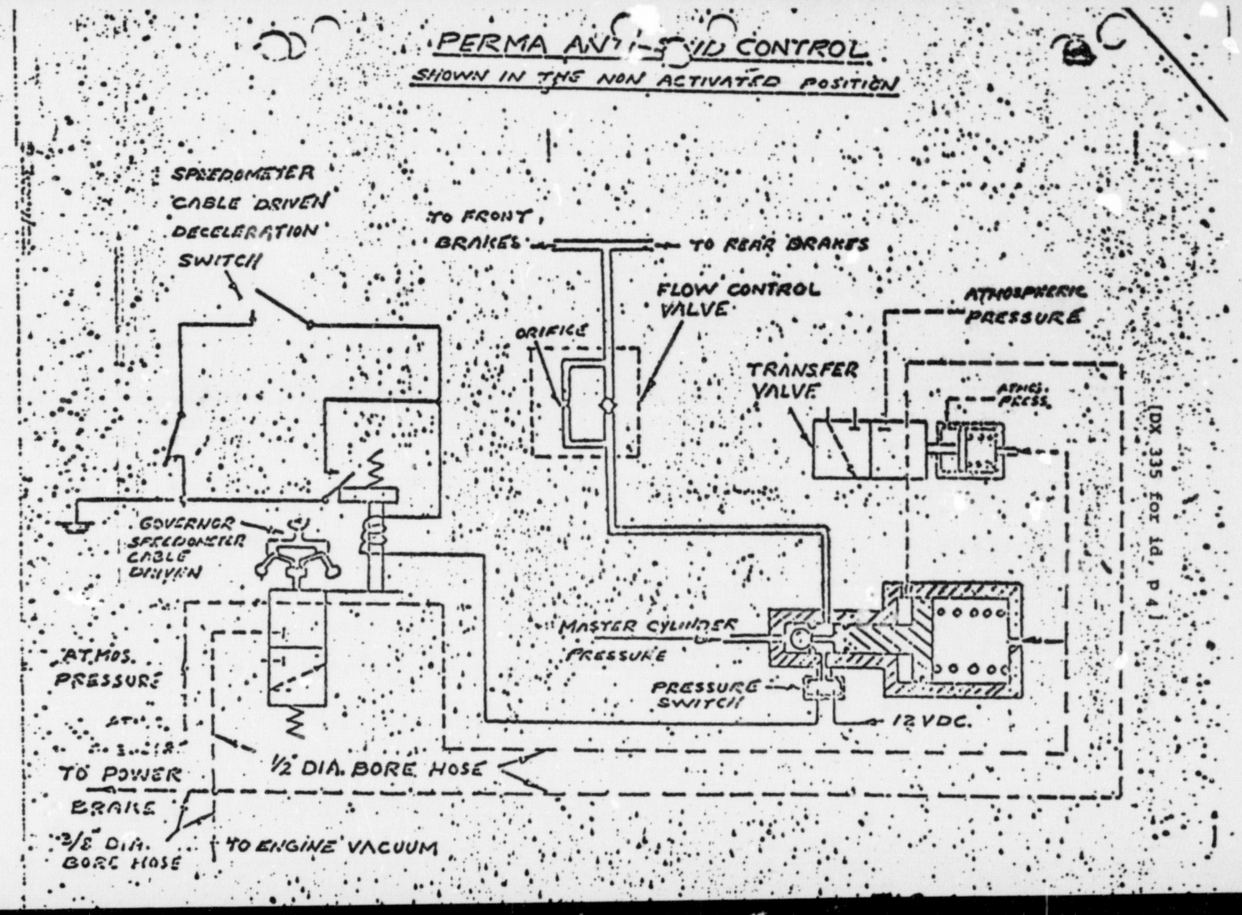
(P. Every?)

(P. Every/mek?)





[DX 335, for id, p 4]




[DX 335 for id, p 4]

February 3, 1966

Kelsey-Hayes Company
Inter-Department Correspondence

D-335
Transcription

To: M. MEYER

From: P. EVERY

Subject: Evaluation of the Perma Anti-Skid System

Object: The object of this evaluation was to determine whether the Perma-Anti-skid System or any of the major components are of value to the Kelsey-Hayes Brake Control System Program.

Summary: A Perma Anti-Skid System was loaned to the Kelsey-Hayes Company for evaluation. The System was installed on the 1965 Chevelle exactly as recommended by Singer except that the intake manifold connection was through a 3/8" diameter bore hose, the recommended size is 1/2" diameter.

The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h., recording the stopping distance and directional stability. All stops were made in a series of violent jerks and at speeds above 40 m.p.h., directional stability was difficult





to maintain and on many of the 60 m.p.h. stops, the brake pedal had to be released to prevent the vehicle from leaving the road. The sensing unit is driven by the speedometer gear, this additional load caused the failure of 3 of these gears during these tests.

The major objection to the system is that the rear wheels are required to lock completely before the brake pressure is reduced which is the primary cause for the instability and jerkiness.

The tests have not indicated that the System or any of its components offer any premise for development in a Kelsey-Hayes System. It must be pointed out here that no instrumentation was used on the system thus the possibility of any system modifications to improve performance cannot be determined accurately.

Test Procedure: The test procedure was simply to make panic stops from speeds between 30 and 60 m.p.h. and recording deceleration, stopping distance and vehicle stability.

[DX 335 for id, p 7]

The following system configurations were tested:

(1) Installed as Singer recommended and shown on Fig. 1.

(2) Without the flow control valve.

(3) Releasing pressure to the rear wheels only.

(4) Releasing pressure to the rear wheels only and without the flow control valve.

(5) Releasing pressure to the rear wheels only, without the flow control valve but with vacuum tank and check valve between the manifold and system.

Test Results: All the 30 m.p.h. stops were stable with little or no steering correction required. When the system was pumping all four brakes the stops were achieved in a series of violent decelerations. When the system was pumping the rear brakes only the decelerations were relatively mild, although possibly acceptable were definitely uncomfortable.

The average stopping distance on wet pavement was the same for four wheel or rear only pumping, and without the system.





[DX 335 for id, p 8]

The majority of the 60 m.p.h. stops required considerable steering correction to keep the car on the road and on several occasions the brake pedal had to be released. The car was generally more easily controlled without the system operating. The few straight stops were achieved when the front wheels locked during the first part of the stop. The stopping distances with the system operating were generally equal to or greater than without the system on wet pavement.

Several occasions one rear wheel locked for 30 feet or more before the other, under these conditions the system can not pump. Generally the car skids a considerable distance before the pumping action could be detected except for the test made in configuration 6, when the system started pumping immediately after the rear wheel locked, however, straight stops could only be achieved by limiting the applied pressure.

The sensing unit is cable driven through an adapter by the speedometer gear, this additional load reduced the gear life to approximately 15 panic stops.

The system is installed under the hood and was achieved easily on the Chevelle but it would be extremely difficult on a car like the Lincoln.

**Conclusions:** On the basis of this test, the system provides no improvement to the normal braking system. Improvement in the system might well be achieved by component modification but this should be preceded by instrumental testing to determine the most effective changes. The writer believes a more sophisticated method of detecting wheel motion is essential to provide an acceptable system and does not recommend any further testing or development work with this system.

P. Every





DEFENDANT'S EXHIBIT 337 FOR IDENTIFICATION

ENGINEERING REPORT — Confidential — P+S 3-18-71

| | |
|---|---|
| TO: Mr. A. E. Samson | DATE: 3-23-66 |
| cc: Mr. J. Brown<br>Mr. O. D. Dillman<br>Mr. D. F. Fiscus<br>Mr. R. Miller<br>Mr. D. P. Renner<br>Mr. A. C. Sampietro<br>Library (2) | E.S.A. NO. 7626<br>W.P.C. NO. 6<br>PROJECT NO.<br>☑ INFORMATION ONLY ☐ RECOMMENDATION |

SUBJECT: Singer Anti-Skid Control Unit

Object: To determine the stopping distance and directional stability under various road conditions of a vehicle equipped with the Singer Anti-Skid Control Unit.

Conclusions:

Test results indicate that the Singer Anti-Skid Control Unit, installed according to the manufacturer's instructions, is ineffective in improving the stopping distance and directional stability of a vehicle on various road surfaces. It was found that on slippery surfaces (coefficient of friction between tire and road equal to or less than 0.5), the device proved inoperative. The inadequacies can be attributed to use of a restrictor valve in the hydraulic system, failure to compare vehicle deceleration with driveline deceleration, and system inertia inher in vacuum lines and pistons.

Recommendations:

After testing the Singer Anti-Skid Control Unit under various conditions, it must be recommended that further testing be discontinued as the device offers no potential in its present state.

Discussion:

Description of Unit

The Singer Anti-Skid Unit consists of two major components; one for sensing driveline rotation (Sensing Unit), the other for modulating the brake line pressure when the rear wheels lock (Perma-Vac Unit). The Sensing Unit is connected to the speedometer drive gear by means of a flexible cable. When the brakes are applied to the point of rear wheel lock-up; driveline rotation ceases and this cessation causes the governor in the sensing unit to actuate a valve. This valve vents the rear section of the Perma-Vac Unit to vacuum, a condition which retracts a piston in the hydraulic system and reduces the brake line pressure to both the front and rear brakes.

As the pressure is reduced, the rear wheels begin to turn again, causing the [illegible] to reposition the valve, venting the rear section of the Perma-Vac Unit to the atmosphere and the front section to intake manifold vacuum. This condition forces the piston into the hydraulic system restoring the brake line pressure to its original value. This sequence of operations continues throughout the skid unt the vehicle speed is reduced to approximately 0 mph, whereupon, full brake line pressure is restored and maintained.

Approved: W.S. Ibaugh D.P.E. 337 Noted: W. J. Callahan

Description of Unit (Con't)

In addition to the above two components, there is a restrictor valve in the brake lines between the Perma-Vac Unit and the wheel cylinders. This valve limits the minimum brake line pressure to approximately 175 psi during the cycling, a condition designed to reduce stopping distance by maintaining contact between the brake shoes and drums.

Vehicle, Instrumentation, and Unit Installation

The vehicle used for the evaluation was a 1966 Ford Custom 500 4-door sedan equipped with the following:

- 390-2V CID engine
- 3-speed automatic transmission
- Power drum brakes
- Power steering
- 7.75 x 15, 4-ply rated tires inflated to 24 psi.

In order to evaluate the anti-skid system, the following instrumentation was installed on the vehicle:

- Wheel rotation indicators (4) - to check for lockup.
- Line pressure indicators (2) - to record front and rear line pressure.
- Accelerometers (2) - to record longitudinal and lateral acceleration.
- Fifth wheel - to record velocity and stopping distance.
- Oscillograph recorder.

With this instrumentation, a driver, and an observer, the vehicle weight was recorded as follows:

Front - 2436 lbs.

Rear - 2116 lbs.

TOTAL - 4552 lbs.









Vehicle, Instrumentation, and Unit Installation (Con't)

The Singer Unit was installed in the test vehicle in such a way that it could be turned off completely, allowing for evaluation of the standard brake system, or be isolated from the front brakes, allowing modulation of the rear brakes only and leaving the front brakes connected directly to the master cylinder. Provision was also made for removing the restrictor valve in order to judge its effect on stopping distance.

Test Procedure

All stops were hands off the wheel panic stops with the car in neutral. Some driving was done between stops in order to maintain cool brakes and thus avoid fade. For each road condition, the car was tested with the anti-skid unit turned off, with it turned on and pulsing four brakes, and with it on but pulsing the two rear brakes only, the front brakes being connected directly to the master cylinder. Stops were run both with and without the hydraulic restrictor valve in the system. The following is a list of road conditions and speeds from which stops were made.

I. With Hydraulic Restrictor Valve

A. Stops from 10, 20 and 30 mph, with four wheels on soaped paint stripe:
   1. With anti-skid off
   2. With anti-skid pulsing four brakes
   3. With anti-skid pulsing rear brakes and constant pressure to front brakes

B. Stops from 10 and 20 mph, with two right wheels on soaped paint stripe and two left wheels on dry asphalt:
   1. With anti-skid off
   2. With anti-skid pulsing four brakes
   3. With anti-skid pulsing rear brakes and constant pressure to front brakes

C. Stops from 10, 20 and 30 mph, with four wheels on wet paint stripe:
   1. With anti-skid off
   2. With anti-skid pulsing four brakes
   3. With anti-skid pulsing rear brakes and constant pressure to front brakes

I. With Hydraulic Restrictor Valve (Con't)

D. Stops from 10, 20 and 40 mph, with four wheels on wet asphalt:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

E. Stops from 10, 20 and 40 mph, with four wheels on dry asphalt:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

II. With Hydraulic Restrictor Valve Removed

A. Stops from 20 and 30 mph, with four wheels on coaped paint strips:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes.

B. Stops from 20 and 30 mph, with four wheels on wet paint strips:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes

C. Stops from 10, 20 and 40 mph, with four wheels on wet asphalt:

1. With anti-skid off
2. With anti-skid pulsing four brakes
3. With anti-skid pulsing rear brakes and constant pressure to front brakes





Summary of Test Results

The attached tables summarize the average stopping distances recorded during the tests. No substantial differences in stopping distance for similar road conditions are indicated.

Visual observation of stability indicated that with the Singer Anti-Skid Unit modulating all four brakes, no increase in stability over the standard vehicle was achieved, and in some cases stability was lessened. Test recordings indicated that four brake modulation induced lateral accelerations in the vehicle and thus decreased its stability. With only the two rear brakes being modulated, a condition not investigated by the manufacturer, some increase in stability over the standard vehicle for some road conditions was recorded. In addition, this was the system favored by the test driver. He commented that the car seemed more stable when only the rear brakes were being modulated.

The restrictor valve that the Singer Company installed in the Anti-Skid Unit detracted from its performance on slippery surfaces. When the pressure was reduced, it never dropped low enough to unlock the rear wheels on even wet paint strips. Consequently, the Unit cycled once and then reapplied full line pressure for the remainder of the stop. Even without the restrictor valve, the Unit did not cycle effectively on coaped paint strips, a road condition which simulated wet ice.

With the Unit modulating all four brakes and without the restrictor valve some improvement in stopping distance over the standard vehicle was recorded on wet paint strips. However, an increase in stopping distance over the standard vehicle was recorded for wet asphalt.

The following is a resume of stopping distances and stability for various conditions of system and road.

Without Restrictor Valve

Average Stopping Distance-Ft.

| DITION AND L SPEED | A/S OFF | A/S ON | A/S ON REAR ONLY |
|---|---|---|---|
| **ls on soaped paint** | | | |
| 20 | 84.6 | 65.0 | 84.5 |
| 30 | 206.3 | 202.9 | 211.3 |
| **ls on wet paint** | | | |
| 20 | 38.8 | 35.9 | 37.6 |
| 30 | 102.8 | 101.1 | 120.7 |
| **ls on wet asphalt** | | | |
| 10 | 3.9 | 4.8 | 3.7 |
| 20 | 14.6 | 21.0 | 15.2 |
| 30 | ---- | 78.5 | 70.2 |

ions are that the coefficient of friction between road and tire was than normal.

c Unit only cycled once.

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| I. With Restrictor Valve | | | | | |
| A. 4-wheels on soaped paint | | | | | |
| 1. Anti-Skid off | 9.7 | 18.6 | | 2" RT | |
| | 9.4 | 16.4 | 6" RT | | |
| | 20.7 | 86.3 | 15° YAW | | |
| | 20.2 | 76.0 | 15° YAW | | |
| | 29.9 | 189.9 | 15° YAW | | |
| | 30.7 | 200.8 | 45° YAW | | |
| 2. Anti-Skid Pulsing four brakes | 9.6 | 19.0 | Stable | | |
| | 9.3 | 17.3 | 6" RT | | |
| | 19.8 | 88.2 | 8" LFT | | |
| | 19.6 | 80.2 | 5° YAW | | |
| | 30.5 | 229.0 | 60° YAW | | |
| | 30.5 | 213.0 | 60° YAW | | |
| 3. Anti-Skid Pulsing rear brakes only | 9.7 | 20.3 | Stable | | 1 |
| | 9.6 | 17.1 | | 6" RT | 1 |
| | 20.2 | 78.1 | 18" RT | | 1 |
| | 20.4 | 83.2 | 6" Sway & Recover | | 1 |
| | 30.3 | 199.5 | Slight Sway | | 1 |
| | 30.5 | 205.5 | Sway & Recover | | 1 |





| CONDITION | SPEED MPH. | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| I B. 2-wheels on soaped paint 2-wheels on dry asphalt | | | | | |
| 1. Anti-Skid off | 9.1 | 7.4 | | 1' RT | |
| | 9.3 | 7.5 | | 1' RT | |
| | 19.0 | 32.4 | 1' LFT | 4' RT | |
| | 19.3 | 30.9 | 1' LFT | 4' RT | |
| 2. Anti-Skid Pulsing four brakes | 9.2 | 7.1 | | 1' RT | 1 |
| | 9.7 | 8.6 | | 1½' RT | 1 |
| | 19.7 | 29.9 | 1' LFT | 4' RT | 4 |
| | 20.1 | 30.1 | 1' LFT | 4' RT | 5 |
| 3. Anti-Skid Pulsing rear brakes only | 10.4 | 9.3 | 1' LFT | 1' RT | 1 |
| | 9.7 | 8.0 | 1½' RT | | 1 |
| | 20.0 | 33.9 | 45° YAW | | 5 |
| | 19.0 | 33.7 | 30° YAW | | 5 |

| CONDITION | SPEED MPH. | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| I C. 4-wheels on wet paint | | | | | |
| 1. Anti-Skid off | 10.0 | 7.8 | Stable | | |
| | 10.0 | 7.9 | Stable | | |
| | 20.2 | 41.3 | 3" RT | | |
| | 20.6 | 48.4 | 1' LFT | 6" RT | |
| | 30.2 | 112.6 | 1' RT | 6" LFT | |
| | 30.7 | 104.8 | 3' RT | 1' LFT | |
| 2. Anti-Skid Pulsing four brakes | 9.7 | 8.6 | Stable | | 2 |
| | 10.0 | 8.5 | Stable | | 1 |
| | 20.2 | 47.5 | 8" RT | | 1 |
| | 20.6 | 32.9 | 1' LFT | | 1 |
| | 30.5 | 130.0 | 3' RT | 1' RT | 1 |
| | 30.9 | 100.9 | 3' RT | 1' RT | 1 |
| 3. Anti-Skid Pulsing rear brakes only | 10.0 | 8.0 | Stable | | 3 |
| | 9.6 | 7.2 | Stable | | 1 |
| | 20.1 | 46.6 | 1' RT | | 1 |
| | 20.8 | 45.5 | 1' RT | | 1 |
| | 30.1 | 95.0 | Sway & Recovery | | 4 |
| | 30.9 | 108.6 | 1' LFT | | 1 |





| CONDITION | SPEED MPH. | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| I D. 4-wheels on wet asphalt | | | | | |
| 1. Anti-Skid | 9.4 | 4.7 | Stable | | |
| | 9.7 | 3.7 | Stable | | |
| | 20.1 | 13.7 | Stable | | |
| | 19.6 | 16.0 | Stable | | |
| | 40.3 | 77.9 | 4" RT | | |
| | 41.0 | 71.5 | 1' RT | | |
| 2. Anti-Skid Pulsing four brakes | 9.6 | 4.5 | Stable | | 0 |
| | 9.7 | 4.8 | Stable | | 0 |
| | 20.1 | 15.8 | Stable | | 3 |
| | 20.5 | 15.2 | Stable | | 3 |
| | 41.6 | 66.1 | 1½' RT | | 7 |
| | 41.1 | 71.1 | 6" LFT Drift RT | | 6 |
| 3. Anti-Skid Pulsing rear brakes only | 10.4 | 4.9 | Stable | | 0 |
| | 9.2 | 4.5 | Stable | | 0 |
| | 20.0 | 16.3 | 2" LFT | | 3 |
| | 20.1 | 15.6 | Stable | | 3 |
| | 40.4 | 74.5 | Stable | | 6 |
| | 40.6 | 69.8 | 3" RT | | 6 |

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYC |
|---|---|---|---|---|---|
| I E. 4-wheels on dry asphalt | | | | | |
| 1. Anti-Skid off | 10.1 | 4.3 | Stable | | |
| | 10.4 | 4.7 | Stable | | |
| | 20.3 | 14.8 | Drift RT | | |
| | 20.5 | 15.7 | Drift RT | | |
| | 40.5 | 68.1 | Drift RT | 1' RT | |
| | 40.7 | 67.4 | | 4" RT | |
| 2. Anti-Skid Pulsing four brakes | 10.0 | 4.3 | Stable | | |
| | 9.7 | 4.7 | Stable | | |
| | 19.8 | 15.9 | Stable | | |
| | 19.6 | 17.3 | | 2" RT | |
| | 39.1 | 71.0 | Drift LFT | 6" RT | |
| | 39.3 | 70.0 | 1' RT | Drift RT | |
| 3. Anti-Skid Pulsing rear brakes only | 9.6 | 4.5 | Stable | | |
| | 9.7 | 4.2 | Stable | | |
| | 19.6 | 16.1 | Stable | | |
| | 19.4 | 17.0 | Stable | | |
| | 39.0 | 72.5 | | 1" RT | |
| | 39.5 | 72.0 | Stable | | |

E-1322





| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYC |
|---|---|---|---|---|---|
| II. Without Restrictor Valve | | | | | |
| A. 4-wheels on coated paint | | | | | |
| 1. Anti-Skid off | 20.2 | 81.5 | 2' LFT | 8" LFT | |
| | 20.2 | 87.7 | 2' LFT | 8' LFT | |
| | 31.0 | 186.5 | 8" RT | | |
| | 30.6 | 155.6 | | 8" RT | |
| 2. Anti-Skid Pulsing four brakes | 19.8 | 63.4 | 1½' RT | 6" LFT | 5 |
| | 20.5 | 66.5 | 1½' RT | 6" LFT | 7 |
| | 30.7 | 218.5 | 60° YAW | | 1 |
| | 30.6 | 187.3 | 70° YAW | | 2 |
| 3. Anti-Skid Pulsing rear brakes only | 20.2 | 91.4 | 15° YAW | | 1 |
| | 19.8 | 77.6 | Sway & Recovery | | 1 |
| | 30.4 | 221.5 | Yaw off Strip | | 2 |
| | 31.0 | 201.0 | Yaw off Strip | | 1 |

E-1323

| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| II B. 4-wheels on wet paint | | | | | |
| 1. Anti-Skid off | 20.4 | 38.8 | 1' RT | 4" LFT | |
| | 29.9 | 106.1 | 30° YAW | | |
| | 30.5 | 99.5 | 30° YAW | | |
| 2. Anti-Skid Pulsing four brakes | 20.4 | 34.4 | Drift RT | | 6 |
| | 20.5 | 37.3 | 1' LFT | | 5 |
| | 30.9 | 97.8 | 45° YAW | | 7 |
| | 31.0 | 104.3 | 30° YAW | | 7 |
| 3. Anti-Skid Pulsing rear brakes only | 20.1 | 39.8 | 6" RT | | 7 |
| | 20.8 | 35.4 | 6" RT | | 7 |
| | 30.5 | 122.6 | 2' LFT | 3' RT | 10 |
| | 30.5 | 118.7 | 2' RT | 1' LFT | 9 |









| CONDITION | SPEED MPH | STOPPING DISTANCE FT. | LATERAL MOVEMENT (STABILITY) FRONT | REAR | NUMBER CYCLES |
|---|---|---|---|---|---|
| II C. 4-wheels on wet asphalt | | | | | |
| 1. Anti-Skid off | 9.7 | 3.8 | Stable | | |
| | 9.5 | 3.9 | Stable | | |
| | 20.4 | 14.9 | Stable | | |
| | 20.4 | 14.6 | Stable | | |
| | 20.5 | 14.4 | Stable | | |
| 2. Anti-Skid Pulsing four brakes | 9.8 | 4.4 | Stable | | 0 |
| | 9.7 | 5.1 | Stable | | 0 |
| | 20.4 | 21.2 | Stable | | 3 |
| | 20.2 | 20.7 | Stable | | 3 |
| | 41.4 | 78.7 | 6" RT | | 6 |
| | 40.8 | 78.2 | 1' LFT | | 6 |
| 3. Anti-Skid Pulsing rear brakes only | 9.4 | 3.9 | Stable | | 0 |
| | 9.8 | 3.5 | Stable | | 0 |
| | 20.6 | 15.4 | Stable | | 3 |
| | 20.8 | 15.0 | | 6" RT | 4 |
| | 40.9 | 71.4 | Slight Sway | | 6 |
| | 41.5 | 69.0 | Slight Sway | | 6 |

DEFENDANT'S EXHIBIT 510 FOR IDENTIFICATION

MEMORANDUM

RECEIVED
OCT 15 1965
MFG. ENG. DEPT.
39

SINGER
CENTRAL RESEARCH LABORATORY
DENVILLE, NEW JERSEY

Copy for H. Sha
H. Rapez
and file.

TO: Mr. J. W. Homberg

FROM: Mr. J. A. Lundin

REFER TO: JAL:ck

DATE: October 7, 1965

SUBJECT: Meeting at Denville Research Laboratory on September 30, 1965.

Subject: Perma Anti-Skid Brake Control System from the Aspect of Functional Design and Reliability.

Present: Messrs. A. Romel and C. Papczun - Elizabeth Factory.
J.W. Homberg and J.A. Lundin - Denville.

Purpose of Meeting:

The meeting was arranged to bring the Central Research Laboratory personnel up to date on the experience acquired by the Elizabeth Factory personnel with the Perma Anti-Skid Brake Control System. The Denville personnel have been requested to assist in a technical evaluation of the Perma Anti-Skid Control from the aspect of functional design within the patent protection claimed and reliability not detractive of existing brake systems.

Discussion:

The discussion was guided by questions prepared in advance and is presented in the same form in this meeting report. The term components refers to units, such as the sensor and Perma-Vac assemblies, and to individual components, such as the rotary valve, governor, pressure switch and solenoid. The term adaptors refers to active units to be supplied in the Perma kits to accommodate vehicle differences.

FUNCTIONAL DESIGN:

1. Are the components functioning in accordance with the intended purpose of each component?

It was stated that the Perma system does not function in the mode of Perma's original claim to cycle near the locked-wheel pressure, but cycles between the pressure switch setting (low limit Perma control of brake fluid pressure) and levels just above locked-wheel pressure.

The transfer valve had to be added to the Perma-Vac unit to apply vacuum to the originally-inactive side of the diaphragm to modify a functional deficiency that set an unacceptable limit on the brake pressure during non-panic braking.

DPE
510







The Perma-Vac unit has functioned on a marginal basis since, in some vehicles, the available vacuum head during panic stop was barely sufficient to draw back the diaphragm and thus the piston to relieve the brake fluid pressure far enough to open the pressure switch. This function is required to reset the anti-skid system. It was stated that presently 14.5 to 15 inches of Hg is required to accomplish this. However, this vacuum level requirement should be dependent on the initial pressure required to achieve locked wheels under the particular test conditions; i. e., the captured brake fluid pressure. It was estimated that possibly one out of twenty tests show a lag (longer-than-normal stopping distance) that may be attributed to this marginal behavior.

The rotary valve was stated to be effective only toward the end of its rotary motion during which it should be transferring the vacuum to the Perma-Vac unit. In this part of its rotary motion a large change in output resulted from small angular rotation. It appears to be intended for the rotary valve to vary the vacuum level and thus the brake fluid pressure as a continuous function of the governor speed (wheel speed) within the speed range of the governor. It apparently does not accomplish this function.

There is no data which will show that the governor is functioning in a smooth, continuous manner within its speed range. There is only proof that it functions as a source of angular momentum to act on the cam gear at wheel lock-up and in fact can be fooled in conjunction with the cam gear and inertial switch by gradual application of brake pressure through the "slipping speed" to a "skid" condition. The "slipping speed" is the range of speed between the speed of the wheel corresponding with the forward motion of the vehicle and locked wheel condition or "skid" condition. Thus it is presently possible to generate a skid without initiating the Perma Anti-Skid Control; when wheels are locked gradually rather than suddenly.

The Perma pressure switch has been modified to function with reasonable accuracy and repeatibility.

Some of the recorded data obtained on test runs with the vehicles were examined. Attention was drawn to the almost uniform time period between pulses as indicated by the brake fluid pressure. This behavior suggests that there is a built-in limit of response time of some component in the system forcing the aforementioned cycling between the locked-wheel pressure switch setting. A reduced period between pulses (greater repetition rate) has been observed under wet road conditions which can be explained by the reduced excursion of brake fluid pressure.

2. Are the components universal in applicability to the vehicles in use and to future models of vehicles?

No, not in the present design configuration. The present design is not applicable to the following:

Manual shift transmissions
Disc brakes
Front wheel drives
Front wheel speedometer take-offs
Other than 12-volt electrical systems.

In addition, the present design has demonstrated some satisfactory results in dual brake systems, but has been unsatisfactory in single brake systems which are presently the standard.

Application to future models of vehicles creates a hazy picture. Automotive manufacturers' products are fraught with economic and competitive changes. The most that can be stated here based on present day trends is that functional design of an anti-skid control system should not be critically dependent on vacuum levels and should be compatible with higher brake fluid pressures.

Also, see discussion of question 3 below..

3. What adaptors to vehicle differences exist in the product kits?

The gear box is available with adapters to the transmission speedometer take-off for all new GM cars. However, on American, Ford, and Chrysler cars the speedometer take-off gear is part of the flexible drive cable and requires cutting into the cable. The gearing is not an exact duplicate in all cases and in some applications changes the speedometer calibration.

The Perma-Vac piston is available in two sizes. One unit 0.5 inch diameter for single brake line systems. Two units 0.343 inch diameter each for dual brake systems.

4. What other adaptors have been found necessary or to be desired for the system to function in diverse installations; i.e., vehicle models where the original Perma system fails to function?

The only item referred to was the experimental restriction check valve ("metering" valve) that has been tried on single brake line systems but is generally undesirable, because of the limited fluid flow in a brake system and danger of obstructing the release of pressure from the wheel cylinders.

5. Have the later adaptors been designed, tested and proved satisfactory?

No.







6. Are all components functioning for all road conditions, speeds and environmental conditions?

Testing of the system over the full range of these conditions has not been completed. Some of the conditions not covered thus far are the following:

Environmental - low temperatures
- high altitude driving
- humidity effects.

Road conditions - icy and slushy roads
- elevation grades or hilly roads.

Speeds - low speeds, 5-15 miles per hour, 15-25 miles per hour.
(There is the possibility of excessive free wheeling at the lowest speeds.)

General - Corrosion (none apparent to date)
- Shelf life of hardware.

RELIABILITY:

1. Have the reliabilities of all the components been determined?

The gear box is considered acceptable.

The sensor unit has been run for 40,000 miles thus far and appears to survive this test. However, there are reliability questions inherent in the design which have not been answered.

(a) Is the expansion spring on the governor mounted and guided in such a manner as to prohibit the spring interfering with the return of the governor extension shaft?

(b) Is there an unvented cavity between the telescoping extension shaft and the main governor shaft which may result in a damping action, particularly if oil gets on the shaft?

(c) A statement was made that the valve mechanical design and the valve leverage appears to be an unreliable design.

(d) The spring return of the solenoid is close to the spring force value of the governor expansion spring. Will the solenoid-return spring over-ride a sticky valve?

Memo to: J. W. Homberg Page 5

(c) The Perma project people raised the question of the reliability of the can gear in the sensor. They seem to feel it may be possible to lock it in the position which would initiate the Perma Control any time the pressure switch was closed.

2. Is the anti-skid system fail-safe? (I.e., does every possible failure in the system restore normal brake control to the driver?)

The present Perma anti-skid control is not fail-safe. A failure of the vacuum in the present configuration results in a differential force on the diaphragm in the Perma-Vac unit of only that created by the spring. This force sets an upper limit on the brake fluid pressure that the driver can apply with the brake pedal. The limited pressure is much smaller than that which the driver could apply if the Perma Control was not connected to the brake system, probably less than 50%.

Specific Questions if not Covered in the Above Items:

1. (Reliability) What is the effect of loss of vacuum (due to leaks, stalled engine, etc.) on original brake system capabilities?

See question 2 above.

2. (Functional) Does reset of the Perma Control occur at approximately 10 mph in a positive manner with any reasonable accuracy? Is system returned to standard braking?

These questions could not be answered. Tests of the control system in vehicles have been limited to speeds of 30, 50 and 70 mph. The answer to these questions would seem to be very important since the low speed is related to bumper-to-bumper driving in traffic and the reset response time becomes a greater percentage of overall Perma Control time.

J. A. Lundin
J. A. Lundin
Development Department 500

cc: Messrs. B. C. Perada
A. Rozel
C. R. Odermann





DEFENDANT'S EXHIBIT 559 FOR IDENTIFICATION

REFERRAL SLIP

| PERSON'S NAME | ROOM NO | INITIAL & DATE |
|---|---|---|
| C. F. | | |
| C. | | R |

| | |
|---|---|
| ☐ PLEASE HANDLE | ☐ FOR YOUR APPROVAL |
| ☐ PLEASE CALL ME | ☐ FOR YOUR INFORMATION |
| ☐ PLEASE COMMENT | ☐ AS REQUESTED |

REMARKS

☐ PLEASE RETURN

FROM B C Peraza DATE 2/12/66

D.P.E.
559

SINGER

MEMORANDUM

TO: Mr. D. C. Person

FROM: A. Romel

DATE: February 17, 1956

SUBJECT: Trip Report to Ford Motor Company

RECEIVED
FEB 19 1956
BURTON C. PERSON

Personnel Contacted:

A. Sampson - Senior Engineer (Advanced Chassis Department)

J. Ihnacik - Principal Engineer (Senior Project Engineer)

H. Hallahan - Brake Engineer

It was apparent at the beginning of our discussion that the above representatives were not fully informed as to the purpose of my visit or the role I would play in the test program. They had been laboring under the impression that I was to be present during the instrumentation and testing phases to review their methods and ensure that the test was conducted to our satisfaction. They were unaware of the fact that an installation was to be made during my visit and stated that it generally takes several weeks to set up a test.

I assured them that Singer had the highest regard as to their ability and integrity, and therefore, it was not our intent to take part in the instrumentation or testing of the device. Furthermore, that we would appreciate their professional opinion as to its merit and would not challenge it. I indicated that I would come out when the tests were conducted if they felt that I could be of some assistance.

We discussed the modifications made to the unit by Singer briefly and in general terms only. I was asked why we wanted a test run and told them that we had only performed tests on dry and wet road surfaces with the new unit. I also told them that the new design had not been tested on a Ford product and that our test facilities were rather limited, especially for low coefficient of friction road testing.

A discussion of the metering concept followed, in which, Mr. Ihnacik indicated that he felt we should limit the pressure drop to approximately 125 p.s.i. to shorten the cycle rather than bringing the pressure down to zero. I stated that our tapes showed a minimum pressure of about 200 p.s.i. when the unit was cycling. After learning this, he stated that the valve would not be necessary. In fact, he was of the opinion that it might cause a problem on low coefficient of friction road surfaces. He then talked about the possibility of modifying the unit before testing, such as, adding a vacuum reserve tank and valving arrangement to isolate the front drums from the system.

He then proposed that we conduct a full set of tests on a 1965 Ford before turning over the unit to them for testing; in that a second negative test result would kill any future prospects. I explained our position as to wanting an evaluation of the present configuration before trying the arrangements he proposed. He agreed to go along with our request.

I learned that Kelsey Hayes had a device under development which was being evaluated by them. Also, that they were not developing a device of their own at this time, but were looking at several other devices. One device, I was told, was similar to ours with the exception that a second sensing device was used to sense linear deceleration, in addition to, angular deceleration of the rear wheels. This second sensor is the pendulum type.

Mr. Ihnacik commented on the violent action of our unit and its possible detrimental effect on the suspension system and back-up plates. He also informed me that pumping the front wheels was not necessary, in that, straight panic stopping was their primary objective. This would cut down the violent reaction somewhat, and also take full advantage of the higher brake distribution on the front wheels. Stopping distance in their opinion is also of utmost importance and they would not tolerate any increase over the conventional brake system.

Their criteria for evaluating stability is based on a panic stop with hands off the wheel. This gives them a common reference point when comparing test runs. My guess is that Kelsey Hayes also uses the standard, and explains why they found no advantage in regards to stability when using our device. We did not use this method during our tests and therefore, stability was not recognized as a problem. Some steering correction was used by our test driver on most of the runs.

As far as using vacuum for a power source is concerned, Mr. Ihnacik indicated that they had no reservations and that in all probability the first device offered to the public would use this source. He also stated that at a later date, a hydraulic system like power steering would probably be used. The use of a vacuum reserve tank was mentioned as a possible safety precaution against vacuum drops. He confirmed our findings that vacuum drops during panic or high deceleration stops were to be expected.

As far as disc brakes and dual master cylinders are concerned, they expect to introduce these rather quickly in the next few years. Discs are to be expected on all four wheels and the anti-skid device introduced would probably be for rear disc brakes to take advantage of its low fade characteristics and resistance to lock-up. Apparently, discs do not lock-up as suddenly as drum brakes do. This certainly would effect the ability of our inertia sensing mechanism to detect lock-up and would increase the driver's ability to "fool" our unit.

The minimum number of cycles per second needed for stability during panic stops was stated to be 10 cycles/sec. by Mr. Ihnacik. We fall far short of this requirement.

The following points were agreed upon in regards to the evaluation of our device.

1. The unit would be tested in its present state on all four wheels first.

2. It will be tried with and without the metering valves.







3. Rear wheel actuation only will be tried.

4. A preliminary evaluation of the modifications made will be conducted during the time interval of acquiring and instrumentation of a test vehicle. An assessment as to whether these modifications would improve the performance over that which was observed on the earlier unit would be made during this time. This assessment would determine how much testing and instrumentation would be done. In any event, the unit will be performance tested.

5. The addition of a vacuum reserve tank and/or any other modifications which they want to try will be done after the above tests have been completed. Mr. Ihnacik will let me know when the test schedule has been established.

A. Romel
A. Rome
Supervisory Engineer
Central Engineering Division

AR:ms

[DX 560 for id, p 1]

DEFENDANT'S EXHIBIT 560 FOR IDENTIFICATION

SINGER

30 ROCKEFELLER PLAZA • NEW YORK 20, N.Y.

MEMORANDUM

TO: Mr. C. F. Bruder

FROM: B. C. Person

DATE: February 25, 1966

REFER TO:

SUBJECT: PERMA ANTI-SKID CONTROL

On February 10, 1966, we forwarded to you a copy of the information reviewed with Mr. Kircher in the meeting to get his agreement on the next steps in our relation with Perma. The attached material is a draft of the highlights of the subsequent meeting between Singer and Perma representatives.

Subsequent to this meeting, I had had a phone call from Mr. Perrino of Perma with the following results:

1. We are still at an impasse in regard to any overall settlement agreement.

2. Perma has rejected our proposal for conducting a retrieval program and refused to submit a counterproposal.

Original Signed by
B. C. Person

ECPilk
Att.

cc: Mr. A. di Scipio ← This copy for

RECEIVED
FEB 28 1966
Alfred di Scipio

#560

E-1336 [DX 560 for id, p 1]

DRAFT

[DX 560 for id, p 2]

SUMMARY OF MEETING WITH PERMA

FEBRUARY 16, 1966

The meeting with Perma on February 16, 1966, resulted in somewhat better results that we anticipated:

1. Although agreement was not reached on an overall settlement, the door for further discussion is still partially open.
2. Agreement on the bases for retrieving the units in the New England area is progressing. Both parties are in agreement on the basic plan and have talked about the details of how a retrieval would be conducted.

Settlement Agreement

The discussion regarding a bases for an overall settlement agreement between Perma and Singer ended with the following proposal by Singer on the table:

1. Resale of the patent application and rights to the U.S. and Canada for $385,000 (plus any amounts owed as a result of the retrieval program discussed below).
   - $20,000 cash down payment.
   - Payment of the balance over a period of time (probably tied to the sale of the units). A specific proposal in this area must be developed.
2. Singer will agree to a value of $600,000 on the inventory of anti-skid components, but retains absolute right to refuse to sell the components except to a third party that meets Singer's approval. (If Perma should interest a company of stature, such as Bendix, we believe the inventory could be sold with adequate protection to Singer's name.)

Mr. Perrino indicated it was impossible for Perma to proceed on this basis,

E-1337 [DX 560 for id, p 2]

primarily because of the restriction on the inventory; and, secondly, because there was no money for a down payment. We indicated we could not move from our position regarding absolute control over the inventory.

Retrieval Program

Agreement was reached on the principal points of a program to retrieve the Perma Anti-Skid units still in the field in the New England area. A detailed plan needs to be completed and put into writing. Also, Mr. Perrino was to check with counsel on one point of the agreement - splitting the payment for Class II items.

The understanding to date is:

1. The costs of the retrieval program will be split as follows: Singer will pay for Class III units and one-half of the Class II units; Perma will pay for Class I units and one-half of the Class II units.
2. Singer will advance the funds required for the retrieval; Perma will pay for their share of the program by increasing the amount of the outstanding note held by Singer. Thus, reimbursement to Singer may be postponed to as late as December, 1969.
3. The agreement will contain a clause that the program is entered into without prejudice to the rights of either party.
4. Customers are to be reimbursed in cash, not with a promise of a new unit.
5. Perma will mail a letter to the customers which has been reviewed and approved by Singer.
6. Perma will remove the units at their facility in North Attleboro, Massachusetts.

BCP:lk
2/17/66





1966-P2
(2)

DEFENDANT'S EXHIBIT 658 FOR IDENTIFICATION

CHECKED BY D Berry
DELIVERED BY Joe Fletcher/Jerome
DATE May 16, 1973
TIME 9

Re: Perma v. Singer

Paul R. DeRensis, Esq.
Poletti Freidin Prashker
Feldman & Gartner
777 Third Avenue
New York, New York 10017

Dear Mr. DeRensis:

Herewith please find, pursuant to your request, one unit of the Perma anti-skid device.

The unit is made available to you upon the condition, accepted by you on September 23, 1971, that it will be used only in connection with the instant action and will not be used in such a manner as to risk bodily harm or injury to any person.

Very truly yours,

Samuel S. Linderman

Enclosures

SSL:bc

cc: Messrs. Chanler
Clark
Gordon

1966-P2
(2)

DEFENDANT'S EXHIBIT 659 FOR IDENTIFICATION

CHECKED BY F. Riley
DELIVERED BY Riley
DATE May 22, 1973
TIME 2:30

Re: Perma v. Singer

Paul R. DeRensis, Esq.
Poletti Freidin Prashker
Feldman & Gartner
777 Third Avenue
New York, New York 10017

Dear Mr. DeRensis:

Pursuant to your request, herewith please find one unit of the Perma anti-skid device.

The unit includes static kit serial No. 2314, adaptor kit No. PRM-207 and a variable kit for a V-8 model Chevrolet produced from 1961 through 1962. It replaces the unit sent to you on May 16, 1973, which you found unsuitable for your purposes.

The unit is made available to you upon the condition, accepted by you on September 23, 1971, that it will be used only in connection with the instant action and will not be used in such a manner as to risk bodily harm or injury to any person.

I would be grateful if you return the unit sent to you last week to our messenger.

Very truly yours,

Samuel S. Linderman

Enclosures
bcc: William C. Chanler, Esq.
Merrell E. Clark, Jr., Esq.
Phillip Cordon, Esq.





DEFENDANT'S EXHIBIT 684 FOR IDENTIFICATION

KELSEY-HAYES COMPANY
ROMULUS, MICHIGAN

June 6, 1974

Mr. Jonathan K. Lagemann
Winthrop, Stimson, Putnam & Roberts
40 Wall Street
New York, N.Y. 10005

Dear Mr. Lagemann:

On a number of previous occasions you have repeatedly requested that we produce our Mr. Every to testify on behalf of Singer in connection with your pending lawsuit on the Perma Anti-Skid System. It is my understanding that you intend to use Mr. Every's testimony to establish a foundation sufficient to introduce a test report written by Mr. Every on 3 February 1966 into evidence.

Kelsey-Hayes will agree to produce Mr. Every to testify for the aforementioned purpose provided the following conditions are met:

i.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to any test procedure any test or any test results utilized, conducted or formulated in connection with any anti-skid braking system other than the so-called Perma Anti-Skid Braking System.

ii.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to the identification, function, design or performance of any anti-skid braking system other than the so-called Perma Anti-Skid Braking System.

iii.) The court will not permit questions to be directed to Mr. Every which relate to or call for a response relating to any communication, contract, license or other business relationship between Kelsey-Hayes and its customers, suppliers, licensees, licensors or contractors.

KELSEY-HAYES COMPANY

Mr. Jonathan K. Lagemann
Winthrop, Stimson, Putnam & Roberts

June 6, 1974
Page 2.

iv.) The court will not permit questions to be directed to Mr. Every which elicit or are intended to elicit identification of or information regarding any of Kelsey-Hayes' customers, suppliers, contractors, licensees, licensors or any development, testing, consulting or design activity Kelsey-Hayes has done therefor or therewith.

v.) Singer will submit to Kelsey-Hayes in writing the questions to be asked of Mr. Every for Kelsey-Hayes prior approval.

We feel the above limitations are necessary in view of the confidential nature of information within Mr. Every's personal knowledge. We also feel that the limitations will not preclude Mr. Every from accurately relating to the court the circumstances and conditions under which he conducted the test discussed in his 3 February 1966 memorandum and hence laying the foundation for such memorandum to be placed into evidence.

As we discussed you will seek to obtain the concurrence of the court to limit Mr. Every's testimony as set forth herein.

Very truly yours,

Henry J. Policinski
Patent Attorney

HJP/es





COURT'S EXHIBIT 1

1966-P2 (2)

file T.L. Taylor Crim. Div. FILES

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
777 THIRD AVENUE
NEW YORK, N. Y. 10017

AREA CODE 212 888-2200
CABLES-POLETFRD
CHARLES POLETTI COUNSEL

JOSE FREIDIN (1900-1966)
MARTIN M. FELDMAN
DAVID B. FRANK
LARRAY GARTNER
HOWARD B. GRAND
HERBERT MORRIS
MILTON H. MOSS
ROBERT PRASHKER
THEODORE PROPP
LAWRENCE M. REILLY
IRA F. ROSENFELD
GEORGE J. SOLOMON

November 30, 1973

Jonathan K. Lagemann, Esq.
Winthrop, Stimson, Putnam & Roberts
40 Wall Street
New York, New York

Re: Perma Research & Development Co. v. The Singer Co., United States District Court, Southern District of New York, 66 Civ. 665

Dear Cord:

On November 27, 1973, we agreed that plaintiff and defendant would, insofar as possible, set forth in letter form one week in advance of the testimony of their respective expert witnesses, the anticipated subject matter of that testimony. Pursuant to that agreement and by way of repetition of our disclosures to you on November 27, I set forth below the anticipated subjects which will be covered by the testimony of Daniel Goor, plaintiff's first expert witness:

1. Competitive anti-skid devices, their technical features and development, with emphasis on the Kelsey Hayes unit;

2. The criteria for marketability of an anti-skid device;

3. Steps necessary to render marketable an unperfected anti-skid device;

4. Whether the Perma anti-skid device was or could have been made marketable and, if not, the modifications necessary to make it marketable;

5. Sales of anti-skid devices manufactured by others.

Mr. Goor's testimony will be based upon his prior professional experience including his familiarity with other

Ct. Ex. 1
12/14/73

[Ct X 1, p 2]



anti-skid devices and relevant literature in the field, his evaluation of the Perma anti-skid device based upon physical models, simulated operation, drawings, prints and schematics of the device and Singer's documents reflecting its evaluation thereof.

Sincerely yours,

Paul R. Grand

PRG:ch



COURT'S EXHIBIT 5
PAGE 6 (PAGE 1 OF EXHIBIT A TO COURT'S EXHIBIT 5)

Exhibit A
Page 1 of 12

[Ct X 5, p 6]

| Mfr. | Car Line | Model Year 1969 Total Production | 1969 Anti-Skid (Percent) | 1969 Anti-Skid (Number) | 1970 Total Production | 1970 Anti-Skid (Percent) | 1970 Anti-Skid (Number) | 1971 Total Production | 1971 Anti-Skid (Percent) | 1971 Anti-Skid (Number) | 1972 Total Production | 1972 Anti-Skid (Percent) | 1972 Anti-Skid (Number) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ford | Mark III/IV | 22,564 | 7.5% | 1,692 | 21,432 | 100.0% | 21,432 | 27,091 | 100.0% | 27,091 | 48,591 | 100.0% | 48,591 |
| | Thunderbird | 49,272 | 0.3 | 148 | 50,364 | 2.2 | 1,108 | 36,055 | 7.3 | 2,632 | 54,695 | 5.8 | 3,172 |
| | Lincoln | N.O. | - | - | 37,695 | 9.9 | 3,732 | 35,551 | 8.5 | 3,021 | 45,969 | 7.8 | 3,586 |
| | Mercury | N.O. | - | - | N.O. | - | - | N.O. | - | - | 174,154 | 0.9 | 1,567 |
| | Other Ford | 2,073,092 | - | - | 1,926,720 | - | - | 2,043,140 | - | - | 2,309,676 | - | - |
| | Total Ford | 2,144,928 | 0.1% | 1,840 | 2,036,211 | 1.3% | 26,272 | 2,141,837 | 1.5% | 32,744 | 2,633,085 | 2.2% | 58,916 |
| GM | Toronado | N.O. | - | - | 25,475 | 1.8 | 459 | 29,265 | 6.6% | 1,931 | 48,920 | 2.8% | 1,369 |
| | Cadillac | N.O. | - | - | N.O. | - | - | N.O. | - | - | 227,713 | 1.0 | 2,277 |
| | El Dorado | N.O. | - | - | 23,842 | 0.6 | 143 | 27,368 | 4.3 | 1,177 | 40,074 | 6.0 | 2,404 |
| | Other GM | 4,415,511 | - | - | 4,046,102 | - | - | 3,499,630 | - | - | 4,309,556 | - | - |
| | Total GM | 4,415,511 | 0% | 0 | 4,095,419 | 0.01% | 602 | 3,556,263 | 0.1% | 3,108 | 4,626,243 | 0.1% | 6,050 |
| Chrysler | Imperial | N.O. | - | - | N.O. | - | - | 11,432 | 2.4% | 263 | 15,794 | 4.0% | 632 |
| | Other Chrysler | 1,479,459 | - | - | 1,311,073 | - | - | 1,244,827 | - | - | 1,315,399 | - | - |
| | Total Chrysler | 1,479,459 | 0% | 0 | 1,311,073 | 0% | 0 | 1,256,259 | 0.02% | 263 | 1,331,193 | 0.05% | 632 |
| | Total 3 Manufacturers | 8,039,898 | 0.02% | 1,840 | 7,442,703 | 0.4% | 26,874 | 6,954,359 | 0.5% | 36,115 | 8,590,501 | 0.7% | 63,598 |

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[Ct Y 5, p 6]

[Ct X 5, p 6 (continued)]

| 1973 Total Production | 1973 Anti-Skid (Percent) | 1973 Anti-Skid (Number) | 1974 (To 3/31/74) Total Production | 1974 (To 3/31/74) Anti-Skid (Percent) | 1974 (To 3/31/74) Anti-Skid (Number) | Totals Total Production | Totals Anti-Skid (Percent) | Totals Anti-Skid* (Number) |
|---|---|---|---|---|---|---|---|---|
| 69,437 | 100.0% | 69,437 | 43,529 | 100.0% | 43,529 | 232,644 | 91.0% | 211,772 |
| 82,711 | 5.9 | 4,880 | 42,752 | 7.4 | 3,164 | 315,849 | 4.8 | 15,124 |
| 58,635 | 7.0 | 4,104 | 31,179 | 8.9 | 2,775 | 209,029 | 8.2 | 17,218 |
| 184,359 | 1.4 | 2,581 | 67,709 | 2.6 | 1,760 | 426,223 | 1.4 | 5,913 |
| 2,393,973 | - | - | 1,359,870 | - | - | 12,105,460 | - | - |
| 2,788,124 | 2.9% | 81,002 | 1,545,039 | 3.3% | 57,228 | 13,289,294 | 3.5% | 250,027 |
| 56,226 | 3.2% | 1,799 | 25,416 | 3.3% | 839 | 185,282 | 3.5% | 6,487 |
| 251,176 | 1.5 | 3,768 | 133,458 | 2.0 | 2,669 | 617,347 | 1.4 | 8,724 |
| 51,451 | 5.6 | 2,881 | 31,488 | 6.2 | 1,952 | 174,223 | 4.9 | 8,557 |
| 5,227,855 | - | - | 2,656,411 | - | - | 24,135,065 | - | - |
| 5,566,708 | 0.2% | 8,448 | 2,846,773 | 0.2% | 5,460 | 25,106,917 | 0.09% | 23,768 |
| 15,667 | 3.8% | 596 | N.O. | - | - | 42,893 | 3.5% | 1,451 |
| 1,570,181 | - | - | 803,753 | - | - | 7,724,692 | - | - |
| 1,585,848 | 0.04% | 596 | 803,753 | 0% | 0 | 7,767,585 | 0.02% | 1,451 |
| 9,940,680 | 0.9% | 90,046 | 5,195,565 | 1.1% | 56,688 | 46,163,706 | 0.6% | 275,241 |

* Note:

| | Total 1969-74 Units | Percent of Total A/S | Percent of Total Production |
|---|---|---|---|
| Anti-Skid as Standard Equipment | 211,772 | 77% | 0.46% |
| Anti-Skid as Optional Equipment | 63,389 | 23 | 0.14 |
| Total | 275,161 | 100% | 0.60% |

[Ct X 5, p 6 (continued)]

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[Ct X 6, p 1]

COURT'S EXHIBIT 6

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

PERMA RESEARCH & DEVELOPMENT COMPANY,

Plaintiff,

- against -

THE SINGER COMPANY,

Defendant.

66 Civ. 665 (KTD)

STIPULATION OF FACTS

IT IS HEREBY STIPULATED AND AGREED by and between the undersigned attorneys a follows:

1. General Motors Corporation, Chrysler Corporation and Ford Motor Company have marketed anti-skid devices as indicated below.

- Ford Motor Company

| Car Line | Model Years Offered |
|---|---|
| Mark III/IV | 1969-1974 (Standard Equipment) |
| Thunderbird | 1969-1974 (Optional Equipment) |
| Lincoln Continental | 1970-1974 (Optional Equipment) |
| Mercury | 1972-1974 (Optional Equipment) |

- The General Motors Corporation

| Car Line | Model Years Offered |
|---|---|
| Oldsmobile Toronado | 1971-1974 (Optional Equipment) |
| Cadillac | 1972-1974 (Optional Equipment) |
| Cadillac El Dorado | 1971-1974 (Optional Equipment) |

- Chrysler Corporation

| Car Line | Model Years Offered |
|---|---|
| Imperial | 1971-1973 (Optional Equipment) |

(a) The General Motors Corporation device marketed as optional equipment on Oldsmobile Toronado, Cadillac and

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Cadillac El Dorado model automobiles is supplied by a division of General Motors Corporation. Anti-skid prices[1] on the 1974 models are $214.00 for El Dorado and Cadillac, and $190.00 for Toronado.

(b) The Chrysler Corporation device was supplied to Chrysler by The Bendix Corporation. This device is no longer offered on any Chrysler Corporation automobiles effective with the 1974 models. The price[1] for the Chrysler Imperial anti-skid device at the end of the 1973 model year was $348.50.

(c) The Ford Motor Company device is supplied by The Kelsey-Hayes Corporation. Anti-skid prices[1] for the 1974 Ford models are: Thunderbird $196.60, Mercury $196.90 and Lincoln Continental $214.70.

2. Attached hereto as Exhibit "A" are copies of the appropriate Ward's Automotive Reports for model years 1969 through March 31, 1974, which set forth the number of new cars produced by General Motors Corporation, Ford Motor Company and Chrysler Corporation for this period and the number of anti-skid devices installed thereon for the model years 1972 to March 31, 1974.

3. The number of new cars produced by General Motors Corporation, Ford Motor Company and Chrysler Corporation and the number of anti-skid units installed thereon during the model years 1969 through 1971 are set forth in Exhibit "B" attached hereto.

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[1] Price listed is the manufacturer's suggested retail price in effect during the model year. These prices are supplied by the automobile manufacturer with a disclaimer stipulation such as that supplied by Ford Motor Company: "The manufactuer's suggested retail prices are suggested prices only and are not intended to determine the prices charged by dealers to their customers on resale." The price of options included as standard equipment is part of the base price of the vehicle.





4. When executed by the attorneys for the parties herein, the facts set forth herein and the Ward's Automotive Reports attached hereto may be relied on by the parties in the same manner and to the same extent as any other fact or exhibit in evidence.

Dated: New York, New York
June 24, 1974

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER

By _____
A Member of the Firm
Attorneys for Plaintiff
Office and P.O. Address:
777 Third Avenue
New York, New York 10017

WINTHROP, STIMSON, PUTNAM & ROBERTS

By _____
A Member of the Firm
Attorneys for Defendant
Office and P.O. Address:
40 Wall Street
New York, New York 10005

[Ct X 6, p 4]

[Ct X 6, p 5]

# Percent of Factory Installed Equipment on U.S. '69 Model Cars

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power Drum Brakes | Front Disc Brakes | Power Door Locks | 2-Way Power Seats | 4-6 Way Power Seats | Power Side Windows | Power Tailgate Windows | '69 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 98.0 | 0.4 | 59.3 | 45.4 | 4.3 | 84.2 | 3.9 | 1.8 | ... | 91.7 | 31.5 | 11.0 | 1.5 | ... | 2.0 | 4.5 | 11.5 | 1,109,039 |
| Corvette | 20.7 | 72.4 | 25.7 | 74.3 | ... | ... | 97.7 | ... | ... | 56.6 | ... | 42.5 | ... | ... | ... | 26.8 | ... | 25,827 |
| Camaro | 72.4 | 11.9 | 48.7 | 40.4 | 10.9 | 85.1 | 3.0 | 2.5 | ... | 72.7 | 10.7 | 22.0 | 0.2 | ... | ... | 0.9 | 5.1 | 470,827 |
| Nova | 68.6 | 5.5 | 24.8 | 9.9 | 62.9 | 79.3 | 0.9 | 0.5 | ... | 38.8 | 2.2 | 7.8 | ... | ... | ... | ... | ... | 269,011 |
| [illegible] | 7.1 | 13.9 | ... | ... | 100.0 | 80.4 | 2.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 6,029 |
| Camaro | 92.7 | 23.9 | 45.8 | 39.2 | 15.0 | 88.6 | 3.6 | 2.8 | ... | 57.3 | 6.7 | 29.0 | ... | ... | 1.4 | ... | ... | 200,213 |
| Firebird | 99.9 | ... | 100.0 | ... | ... | 85.0 | 7.6 | 2.5 | 7.3 | 90.3 | 53.8 | 41.0 | 4.4 | ... | 8.4 | 15.5 | 13.2 | 322,439 |
| Chevelle | 99.1 | 0.6 | 100.0 | ... | ... | 84.7 | 33.9 | 2.1 | ... | 90.7 | ... | 50.9 | 9.5 | ... | 17.6 | 53.5 | ... | 112,456 |
| Tempest | 83.3 | 10.5 | 25.1 | 63.1 | 11.8 | 89.7 | 5.2 | 3.4 | 3.5 | 88.9 | 22.5 | 26.7 | 0.4 | ... | 1.1 | 2.7 | 2.8 | 226,214 |
| Firebird | 75.1 | 13.5 | ... | 85.8 | 14.2 | 82.6 | 6.2 | 3.7 | 5.5 | 85.4 | 20.3 | 24.8 | ... | ... | 1.2 | 3.5 | ... | 73,241 |
| Chevelle | 93.9 | ... | 27.3 | 22.7 | ... | 78.1 | 18.9 | 4.2 | 21.9 | 59.8 | 6.9 | 13.3 | 9.5 | 9.8 | 24.4 | 30.4 | ... | 368,870 |
| Tempest | 100.0 | ... | 92.2 | 7.8 | ... | 47.9 | 51.0 | 13.4 | 61.1 | 100.0 | 46.8 | 53.2 | 22.0 | ... | 80.9 | 88.9 | ... | 28,456 |
| Full | 93.4 | 4.9 | 82.1 | 15.5 | 2.4 | 87.0 | 9.0 | 3.6 | 4.4 | 99.4 | 63.9 | 10.7 | 1.7 | ... | 3.5 | 6.3 | 16.6 | 239,269 |
| Buick | 100.0 | ... | 69.6 | 31.4 | ... | 78.3 | 19.6 | 3.6 | 20.5 | 99.7 | 92.2 | 3.9 | 9.7 | 1.3 | 31.4 | 37.3 | ... | 423,329 |
| Riviera | 100.0 | ... | 59.7 | 0.3 | ... | 49.5 | 48.9 | 10.2 | 29.5 | 100.0 | 88.8 | 11.2 | 15.0 | ... | 73.5 | 87.3 | ... | 73,872 |
| Skylark | 59.3 | 0.9 | 35.8 | 60.2 | 4.0 | 80.6 | 6.5 | 2.0 | 4.7 | 95.3 | 51.5 | 3.4 | 1.9 | ... | 3.8 | 6.0 | 13.9 | 185,613 |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | 74.3 | 31.1 | 41.2 | 93.6 | 100.0 | ... | 100.0 | 67.3 | 5.4 | 53.1 | 100.0 | ... | 156,504 |
| Electra | 100.0 | ... | 100.0 | ... | ... | 9.5 | 16.1 | 74.3 | 99.9 | 100.0 | ... | 100.0 | 80.0 | 2.8 | 57.2 | 100.0 | ... | 23,333 |
| Tot. GM Units | 3,958,468 | 193,222 | 2,639,540 | 1,413,103 | 356,034 | 3,492,819 | 454,506 | 218,936 | 482,235 | 3,871,559 | 1,712,530 | 1,011,535 | 318,573 | 52,790 | 585,146 | 784,616 | 273,542 | 4,415,511 |
| % Total Output | 90.6 | 4.4 | 59.8 | 32.1 | 8.1 | 79.1 | 10.3 | 5.0 | 11.0 | 87.7 | 38.8 | 22.9 | 7.2 | 1.2 | 13.2 | 17.8 | 6.2 | |
| Ford | 93.0 | 0.1 | 41.2 | 56.9 | 1.9 | 85.0 | 6.9 | 2.3 | ... | 99.7 | 2.0 | 62.9 | 1.7 | ... | 3.7 | 4.5 | 20.2 | 856,343 |
| Falcon | 86.6 | 4.6 | 25.3 | 61.5 | 13.2 | 85.5 | 2.5 | ... | ... | 71.8 | ... | 25.3 | ... | ... | 0.3 | 0.5 | 6.0 | 305,918 |
| Fairlane | 72.5 | ... | ... | 29.8 | 70.2 | 70.6 | ... | ... | ... | 30.9 | ... | 3.5 | ... | ... | ... | ... | 6.9 | 65,571 |
| Mustang | 69.4 | ... | ... | ... | 100.0 | 69.4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 42,678 |
| Mercury | 71.1 | 11.7 | 26.9 | 54.7 | 18.4 | 88.1 | 4.8 | 4.2 | ... | 65.9 | ... | 30.5 | ... | ... | ... | ... | ... | 293,824 |
| Torino/Fairlane | 100.0 | ... | 100.0 | ... | ... | 43.9 | 39.8 | 16.3 | 34.4 | 100.0 | ... | 100.0 | 40.4 | ... | 59.7 | 86.6 | ... | 49,272 |
| Montego | 59.7 | ... | 100.0 | ... | ... | 73.5 | 17.3 | 7.1 | 7.7 | 99.6 | ... | 91.3 | 9.9 | ... | 25.9 | 26.1 | 22.6 | 142,515 |
| Montego | 92.4 | 1.8 | 7.8 | 79.1 | 13.1 | 90.5 | 3.6 | ... | ... | 82.9 | ... | 31.7 | ... | ... | 0.9 | 1.5 | 6.6 | 117,621 |
| Cougar | 83.3 | 3.1 | 100.0 | ... | ... | 20.3 | 11.3 | 5.6 | ... | 92.4 | ... | 53.9 | ... | ... | ... | 6.3 | ... | 100,322 |
| Lincoln | 100.0 | ... | 100.0 | ... | ... | 31.2 | 41.7 | 21.6 | 99.6 | 100.0 | ... | 100.0 | 79.6 | 48.1 | 95.2 | 100.0 | ... | 38,316 |
| Mark III | 100.0 | ... | 100.0 | ... | ... | 12.1 | 59.2 | 28.5 | 99.8 | 100.0 | ... | 100.0 | 83.1 | 37.1 | 98.3 | 100.0 | ... | 22,534 |
| Tot. Ford Units | 1,529,552 | 57,751 | 902,626 | 1,002,459 | 229,833 | 1,763,591 | 178,922 | 71,232 | 88,448 | 1,770,116 | 18,002 | 1,088,655 | 97,902 | 2,681 | 158,953 | 190,551 | 207,825 | 2,144,928 |
| % Total Output | 53.0 | 2.7 | 42.0 | 47.3 | 10.7 | 82.2 | 8.2 | 3.3 | 4.1 | 82.5 | 0.8 | 50.8 | 4.6 | 0.1 | 7.4 | 8.9 | 9.6 | |
| Rally | 53.6 | | 63.1 | 29.1 | 1.8 | 87.3 | 2.1 | 2.0 | ... | 95.9 | 43.8 | 8.8 | 1.6 | ... | 2.2 | 2.5 | 14.6 | 383,213 |
| Skylark | 75.4 | 20.9 | 87.3 | 5.4 | 7.3 | 83.5 | 2.4 | 3.9 | ... | 67.4 | 8.5 | 4.3 | ... | ... | ... | 0.6 | 6.2 | 224,357 |
| Barracuda | 83.4 | 11.6 | 56.8 | 20.8 | 22.4 | 88.1 | 5.5 | ... | ... | 61.8 | 6.0 | 8.8 | ... | ... | ... | ... | ... | 25,672 |
| Valiant | 83.9 | 0.2 | 66 | 1.3 | 92.1 | 71.0 | ... | ... | ... | 37.8 | 1.6 | 1.4 | ... | ... | ... | ... | ... | 79,351 |
| Polara | 55.8 | ... | 43.1 | 51.9 | ... | 69.3 | 3.6 | 2.8 | ... | 97.6 | 66.1 | 11.1 | 3.6 | ... | 5.7 | 6.0 | 15.2 | 120,553 |
| Coronet | 87.4 | 3.4 | 83.6 | 10.0 | 6.4 | 84.9 | 1.8 | 1.8 | ... | 83.6 | 17.4 | 3.2 | ... | ... | ... | 0.5 | 9.5 | 148,184 |
| Charger | 53.1 | 8.8 | 57.6 | 41.9 | 0.5 | 81.2 | 6.6 | 8.6 | ... | 93.7 | 44.5 | 15.6 | ... | ... | ... | 5.1 | ... | 81,134 |
| Dart | 88.4 | 7.1 | 29.4 | 6.0 | 64.6 | 81.5 | 1.7 | ... | ... | 57.1 | 7.3 | 2.5 | ... | ... | ... | ... | ... | 163,539 |
| Charger | 59.9 | ... | 59.0 | 10.0 | ... | 78.4 | 11.5 | 8.4 | 13.3 | 59.8 | 54.0 | 30.7 | 9.5 | ... | 25.5 | 27.9 | 10.1 | 226,711 |
| Imperial | 100.0 | ... | 100.0 | ... | ... | 25.2 | 41.8 | 32.7 | 99.7 | 100.0 | ... | 100.0 | 68.2 | ... | 95.1 | 100.0 | ... | 20,018 |
| Tot. Chrysler Units | 1,345,697 | 84,597 | 989,104 | 271,175 | 219,179 | 1,226,378 | 57,800 | 55,351 | 50,111 | 1,224,[illegible] | 443,613 | 280,591 | 45,309 | ... | 91,296 | 94,495 | 123,553 | 1,479,459 |
| % Tot. Output | 51.0 | 5.7 | 66.9 | 18.3 | 14.8 | 82.9 | 3.9 | 3.7 | 3.4 | 82.[illegible] | 30.0 | 12.2 | 3.1 | ... | 6.2 | 6.4 | 8.4 | |
| American Motors | 78.6 | 4.5 | 2.8 | 33.1 | 44.1 | 63.6 | 2.0 | 1.2 | ... | 50.7 | 27.6 | 8.[illegible] | ... | ... | ... | 1.4 | 6.8 | 243,462 |
| Tot. AMC Units | 155,197 | 11,051 | 6,219 | 120,552 | 103,631 | 156,055 | 4,905 | 2,904 | ... | 144,562 | 67,919 | 20,153 | ... | ... | ... | 3,438 | 16,637 | |
| Tot. Industry Units | 7,470,324 | 346,523 | 4,538,489 | 2,827,709 | 913,727 | 6,639,403 | 692,323 | 348,423 | 620,794 | 7,010,546 | 2,242,064 | 2,300,937 | 461,784 | 55,478 | 836,035 | 1,073,100 | [illegible],637 | 8,225,385 |
| % Total Output | 90.8 | 4.2 | 54.8 | 34.2 | 11.0 | 80.1 | 8.4 | 4.2 | 7.5 | 84.6 | 27.1 | 27.8 | 5.6 | 0.6 | 10.1 | 13.0 | 7.5 | |

Note: Chrysler Corp. installation rates are based on cars built in both U.S. and Canada for sale in the U.S. only. A production cutoff date of [illegible] was set for Corvette, Camaro and Firebird when the '69 [illegible] for these three lines averages the November-December of calendar year 1968. Marketed production is through July 31, 1969. Ford Motor Co. totals do not include [illegible] cars built prior to Aug. 1, 1968.

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# Percent of Factory Installed Equipment on U.S. '69 Model Cars

| | Bucket Seatline | Vinyl Roof | White Sidewall Tires | Tinted Windshield | Tinted Windshield & Other Windows | Air Conditioning | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Column | Speed Regulating Devices | SW Luggage Rack | Reclining Front Seats | Dual Exhausts | '69 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 24 | 37.2 | 66.4 | 3.8 | 70.8 | 62.1 | 4.9 | 14.2 | 60.3 | ... | 2.5 | 14.2 | 22.1 | 6.4 | 1.8 | 6.7 | ... | 3.4 | 1,102,639 |
| Corvette | 100.0 | 9.2 | | | 80.5 | 29.9 | 94.8 | ... | 24.1 | 100.0 | | 100.0 | | 27.2 | ... | | ... | 100.0 | 25,557 |
| Chevelle | 15.9 | 33.8 | 52.6 | 0.9 | 60.5 | 34.3 | 14.5 | ... | 49.4 | ... | 25.0 | ... | 20.1 | 2.1 | ... | 2.6 | ... | 13.8 | 422,727 |
| Nova | 4.4 | 17.9 | 45.2 | 1.6 | 31.5 | 11.2 | 7.0 | ... | 38.1 | ... | 7.0 | ... | 4.8 | ... | ... | ... | ... | 7.5 | 269,011 |
| Camaro | 54.0 | | 54.6 | 0.1 | 25.8 | | 7.8 | 54.0 | 13.4 | ... | ... | ... | 10.9 | 2.6 | ... | ... | ... | 10.9 | 6,500 |
| Camaro | 100.0 | 41.1 | 47.5 | 1.2 | 47.2 | 18.1 | 21.0 | ... | 46.2 | ... | 19.2 | ... | 21.7 | 3.0 | ... | ... | ... | 26.1 | 202,213 |
| Firebird | 0.2 | 45.2 | 92.3 | 22.9 | 64.8 | 74.4 | 7.7 | 31.3 | 62.0 | ... | 2.6 | 35.5 | 18.5 | 13.9 | 5.2 | 6.0 | 0.2 | 24.5 | 332,419 |
| Grand Prix | 58.7 | 85.5 | 95.2 | 15.5 | 78.1 | 83.2 | 21.6 | 52.8 | 10.3 | ... | 30.9 | 100.0 | | 37.0 | 10.5 | ... | 3.5 | 100.0 | 112,156 |
| Tempest | 54.2 | 44.9 | 79.1 | 31.3 | 40.1 | 45.4 | 13.8 | ... | 66.4 | ... | 22.4 | | 25.2 | 3.3 | 0.5 | 1.3 | 0.5 | 27.0 | 283,244 |
| Firebird | 53.0 | 42.5 | 65.0 | 35.7 | 28.3 | 31.1 | 12.9 | ... | 58.4 | ... | 30.8 | | 23.7 | 6.5 | 0.6 | ... | ... | 21.6 | 73,141 |
| Catalina | 1.9 | 67.0 | 94.1 | 23.9 | 68.7 | 80.2 | 8.1 | 74.1 | 20.8 | ... | | 37.8 | 18.3 | 22.1 | 6.6 | ... | ... | 0.8 | 369,970 |
| Tempest | 7.2 | 85.5 | 90.4 | 6.6 | 91.2 | 95.2 | | ... | 55.3 | ... | 16.1 | 100.0 | | 67.2 | 19.2 | ... | ... | 100.0 | 28,154 |
| Bonneville | 26.3 | 39.3 | 83.0 | 20.0 | 57.2 | 66.9 | 11.0 | ... | 70.7 | ... | 16.1 | | 19.9 | 6.1 | 1.5 | 8.1 | ... | 4.6 | 233,269 |
| Buick | 0.7 | 65.6 | 93.3 | 23.3 | 70.6 | 79.8 | 7.9 | 79.8 | 15.9 | ... | 2.6 | 37.4 | 30.6 | 25.3 | 11.0 | ... | 0.1 | 1.9 | 423,969 |
| Riviera | 28.7 | 84.9 | 95.0 | 7.9 | 89.6 | 94.9 | 18.5 | 42.6 | 5.0 | ... | 52.4 | 100.0 | | 100.0 | 19.5 | ... | 4.8 | 100.0 | 52,872 |
| Special | 6.7 | 41.1 | 88.1 | 34.2 | 52.7 | 64.0 | 6.1 | | 78.5 | ... | 8.8 | | 37.6 | 9.7 | 1.8 | 9.5 | 0.3 | 6.9 | 184,913 |
| Oldsmobile | | 23.1 | 58.9 | ... | 93.0 | 97.2 | 12.8 | 100.0 | | ... | ... | 100.0 | ... | 51.7 | 21.0 | ... | ... | ... | 153,924 |
| Delmont | | | | | | | | 100.0 | | ... | ... | 100.0 | ... | 78.6 | 36.0 | ... | ... | ... | 23,333 |
| Eldorado | 2.7 | 92.0 | 59.5 | | 93.3 | 99.5 | | | | ... | | | | | | | | | |
| GMC Units | 776,597 | 2,075,518 | 3,322,893 | 601,575 | 2,796,300 | 2,648,567 | 441,558 | 1,197,378 | 2,060,179 | 25,887 | 427,684 | 1,034,178 | 863,483 | 611,646 | 197,407 | 149,402 | 8,624 | 656,304 | 4,415,511 |
| % Tot. Output | 17.6 | 47.0 | 75.3 | 13.6 | 63.3 | 60.0 | 10.0 | 27.1 | 45.7 | 0.6 | 9.7 | 23.4 | 19.6 | 13.9 | 4.5 | 3.4 | 0.2 | 14.9 | |
| Ford | 2.0 | 30.9 | 79.4 | 5.8 | 62.6 | 64.3 | 4.0 | 27.7 | 47.5 | ... | ... | 28.2 | 11.8 | 2.9 | 1.6 | 12.9 | 1.8 | 2.2 | 956,343 |
| Fairlane | 10.2 | 22.3 | 80.9 | 1.5 | 35.5 | 27.3 | 7.9 | 8.9 | 33.8 | 22.3 | 1.9 | ... | 11.7 | ... | ... | 4.0 | ... | 14.3 | 355,911 |
| Falcon | 5.0 | 3.5 | 48.7 | 0.9 | 32.5 | 15.1 | | 5.0 | 41.0 | ... | ... | ... | ... | ... | ... | 4.4 | ... | NA | 65,071 |
| Maverick | | | 55.8 | | | 12.2 | | | 77.4 | ... | ... | ... | ... | ... | ... | ... | ... | NA | 43,818 |
| Mustang | 93.4 | 16.1 | 84.6 | 0.5 | 38.3 | 23.2 | 8.6 | 30.1 | 29.9 | 26.9 | 0.6 | 23.0 | 4.4 | 3.2 | 0.2 | ... | ... | 23.2 | 299,824 |
| Thunderbird | 34.0 | 88.0 | 95.1 | | 88.8 | 89.0 | 9.0 | 69.4 | 30.6 | ... | | 100.0 | | 67.2 | 15.2 | ... | 11.1 | 100.0 | 49,272 |
| Mercury | 2.8 | 46.9 | 92.8 | 4.0 | 80.7 | 76.0 | 6.4 | 51.3 | 30.7 | 3.7 | 0.5 | 56.3 | 7.9 | 18.7 | 7.8 | 18.0 | 4.8 | 11.8 | 140,516 |
| Montego | 5.1 | 23.5 | 85.6 | 4.3 | 45.1 | 40.1 | 3.5 | | 63.6 | ... | 1.4 | | 11.7 | | | 4.9 | ... | 9.3 | 117,621 |
| Cougar | 98.3 | 54.1 | 93.8 | 3.1 | 57.0 | 53.3 | 3.9 | 58.1 | 28.1 | ... | 3.2 | 27.8 | 9.6 | 9.5 | 1.1 | ... | ... | 21.9 | 103,772 |
| Lincoln | 4.9 | 83.6 | 98.9 | | 99.5 | 99.3 | 13.7 | 81.2 | 18.8 | ... | | 100.0 | | 49.7 | 29.1 | ... | 16.8 | 100.0 | 38,315 |
| Mark III | | 53.6 | 97.3 | | 93.9 | 99.8 | 19.8 | 100.0 | | ... | | 100.0 | | 76.1 | 48.1 | ... | 34.1 | 100.0 | 22,564 |
| Ford Units | 480,675 | 654,312 | 1,752,514 | 72,954 | 1,158,660 | 1,076,213 | 122,276 | 592,485 | 872,696 | 167,679 | 14,242 | 568,543 | 196,571 | 140,244 | 56,968 | 164,101 | 42,222 | 320,816 | 2,144,928 |
| % Tot. Output | 22.4 | 31.0 | 81.7 | 3.4 | 54.0 | 50.2 | 5.7 | 27.6 | 40.7 | 7.8 | 0.7 | 26.5 | 9.2 | 6.5 | 2.7 | 7.6 | 2.0 | 14.1 | |
| Fury | 4.5 | 30.6 | 76.3 | 23.0 | 55.2 | 67.0 | 6.2 | 7.6 | 65.5 | ... | 0.1 | 70.7 | 1.0 | 1.6 | 1.7 | 6.9 | 1.7 | 5.4 | 343,213 |
| Belvedere | 22.7 | 34.6 | 85.5 | 30.5 | 28.0 | 28.3 | 27.6 | ... | 51.2 | ... | 18.3 | | 4.7 | ... | 0.5 | 3.9 | ... | 43.8 | 229,357 |
| Barracuda | 70.3 | 29.5 | 64.3 | 29.7 | 25.9 | 21.7 | 16.6 | | 77.9 | ... | 0.4 | | 6.3 | ... | | | | 20.8 | 25,472 |
| Valiant | 1.2 | 5.3 | 52.5 | 22.3 | 12.1 | 16.0 | 2.5 | | 57.4 | ... | | | | | | | | | 79,331 |
| Polara | 6.0 | 45.0 | 82.6 | 18.5 | 65.6 | 70.9 | 7.6 | 13.2 | 79.2 | ... | 0.1 | | 30.7 | 4.0 | 6.3 | 8.9 | 7.7 | 13.9 | 126,550 |
| Coronet | 17.2 | 40.9 | 84.3 | 27.4 | 36.5 | 33.6 | 12.6 | ... | 73.2 | ... | 6.4 | 14.1 | 4.7 | ... | 0.9 | 5.7 | ... | 22.0 | 181,104 |
| Charger | 100.0 | 87.8 | 96.3 | 26.1 | 50.7 | 50.5 | 21.9 | | 73.6 | ... | 19.9 | 100.0 | ... | ... | 2.5 | ... | ... | 42.7 | 84,104 |
| Dart | 12.7 | 35.1 | 70.1 | 25.8 | 17.6 | 23.1 | 8.9 | | 60.1 | ... | 0.1 | | | | | | | 13.8 | 163,539 |
| Chrysler | 9.8 | 55.2 | 93.4 | 13.2 | 78.5 | 60.4 | 10.0 | 90.8 | 9.2 | ... | | 19.2 | 32.4 | 8.0 | 11.3 | 7.4 | 17.2 | 10.0 | 235,711 |
| Imperial | 12.2 | 99.0 | 58.5 | | 58.8 | 98.9 | 24.1 | 100.0 | | ... | | 100.0 | | 60.9 | 50.5 | | 79.0 | | 20,018 |
| Chrysler Units | 254,154 | 610,302 | 1,214,605 | 340,937 | 533,737 | 758,052 | 182,857 | 268,925 | 822,720 | ... | 70,318 | 416,270 | 137,157 | 40,961 | 56,345 | 71,147 | 70,591 | 257,824 | 1,479,459 |
| % Tot. Output | 17.2 | 41.3 | 82.1 | 23.0 | 36.1 | 51.2 | 12.4 | 18.2 | 55.6 | ... | 4.8 | 8.1 | 9.3 | 2.8 | 3.8 | 4.8 | 4.8 | 17.4 | |
| American Mtrs. | 22.2 | 15.8 | 53.8 | 19.1 | 30.1 | 38.9 | 11.1 | 28.9 | 28.4 | ... | 5.0 | 14.4 | 18.7 | 9.1 | 2.7 | 15.3 | 40.7 | 10.2 | |
| Tot. AMC Units | 54,790 | 35,555 | 148,829 | 47,182 | 74,265 | 95,697 | 27,237 | 71,135 | 70,097 | ... | 12,280 | 35,542 | 46,122 | 22,423 | 6,692 | 37,739 | 120,045 | 25,114 | 246,652 |
| Tot. Indus. Units | 1,565,126 | 3,339,037 | 6,438,342 | 1,063,051 | 4,563,032 | 4,578,709 | 773,978 | 2,129,923 | 3,825,692 | 193,566 | 524,724 | 2,054,533 | 1,243,333 | 815,274 | 317,412 | 422,289 | 241,432 | 1,242,003 | 8,286,260 |
| % Tot. Output | 18.9 | 40.9 | 77.7 | 12.8 | 55.1 | 55.3 | 9.3 | 25.7 | 46.2 | 2.3 | 6.3 | 24.8 | 15.0 | 9.8 | 3.8 | 5.1 | 2.9 | 15.0 | |

NOTE: All Chrysler Corp. units shown are based on cars built in both U.S. and Canada for sale in the U.S. only. A production cutoff date of July 31, 1969, was set for Corvette, Camaro and Firebird when the '69 models run for these three lines was extended into November-December of calendar year 1969. Maverick production is through July 31, 1969. Ford Motor Co. totals do not include 7,770 Mark III cars built prior to Aug. 1, 1968.



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E-1352

# Percent of Factory Installed Equipment on U.S. '70 Model Cars

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power Drum Brakes | Front Wheel Disc Brakes | Power Door Locks | 2-Way Power Seats | 4-6 Way Power Seats | Power Side Windows | Power Tailgate Windows | '70 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 97.9 | ... | 63.9 | 33.6 | 2.5 | 87.1 | 5.2 | 2.2 | ... | 95.2 | 16.2 | 44.3 | 2.0 | ... | 2.5 | 4.7 | 14.3 | 831,135 |
| Corvette | 23.5 | 70.6 | 38.4 | 61.6 | ... | ... | 99.1 | ... | ... | 68.8 | ... | 61.9 | ... | ... | ... | 27.8 | ... | 17,015 |
| Chevelle | 68.6 | 9.9 | 44.9 | 49.6 | 6.5 | 89.6 | 3.9 | 4.5 | ... | 82.5 | 9.1 | 31.6 | 1.0 | ... | ... | 1.2 | 5.6 | 402,015 |
| Nova | 72.1 | 5.3 | 31.4 | 12.8 | 55.1 | 85.5 | 1.1 | 1.3 | ... | 50.1 | 2.4 | 8.2 | ... | ... | ... | ... | ... | 219,122 |
| Monte Carlo | 99.5 | 1.0 | 49.6 | 51.4 | ... | 81.6 | 13.0 | 8.2 | ... | 99.3 | ... | 100.0 | 0.7 | ... | 0.7 | 10.7 | ... | 140,015 |
| Camaro | 73.1 | 15.0 | 45.1 | 44.8 | 10.1 | 83.7 | 6.9 | ... | ... | 74.2 | ... | 47.7 | ... | ... | ... | ... | ... | 220,015 |
| Pontiac | 99.8 | ... | 100.0 | ... | ... | 82.4 | 14.1 | 2.6 | ... | 99.5 | 38.0 | 54.9 | 6.0 | 0.2 | 8.4 | 18.4 | 15.2 | 487,345 |
| Grand Prix | 99.2 | 0.5 | 100.0 | ... | ... | 59.3 | 38.2 | 7.4 | ... | 99.8 | ... | 100.0 | 7.8 | ... | 16.0 | 55.0 | ... | 61,015 |
| Firebird | 98.7 | 6.8 | 17.4 | 79.4 | 7.2 | 87.8 | 7.3 | 3.3 | ... | 99.0 | 23.5 | 30.9 | 0.7 | ... | 1.1 | 2.7 | 3.9 | 211,015 |
| Ford | 80.3 | 9.0 | 61.3 | 32.8 | 6.4 | 85.2 | 12.2 | 5.3 | ... | 92.1 | ... | 163.0 | 1.0 | ... | ... | ... | ... | 489,158 |
| Cougar | 100.0 | .... | 65.0 | 15.0 | ... | 80.0 | 17.0 | 4.0 | ... | 100.0 | ... | 99.0 | 12.0 | 3.0 | 32.0 | 4.0 | ... | 200,015 |
| Torino | 100.0 | ... | 79.0 | 21.0 | ... | 45.0 | 54.0 | 15.0 | ... | 100.0 | ... | 100.0 | 26.0 | ... | 69.0 | 92.0 | ... | 356,158 |
| Mustang | 99.0 | 3.0 | 75.0 | 23.0 | 2.0 | 89.0 | 6.0 | 4.0 | ... | 97.0 | 42.0 | 39.0 | 2.0 | ... | 3.0 | 7.0 | 12.0 | 211,015 |
| Maverick | 100.0 | ... | 71.5 | 28.5 | ... | 72.4 | 25.5 | 3.6 | ... | 99.9 | 91.1 | 6.7 | 13.6 | 0.4 | 33.5 | 33.4 | 6.2 | 427,158 |
| Ranchero | 100.0 | ... | 100.0 | ... | ... | 40.0 | 53.6 | 10.4 | ... | 100.0 | 80.4 | 10.6 | 21.3 | ... | 76.5 | 89.5 | ... | 21,158 |
| Econoline | 97.7 | 1.1 | 27.8 | 69.3 | 2.9 | 88.7 | 7.6 | 1.8 | ... | 96.1 | 48.8 | 5.6 | 1.3 | ... | 2.6 | 2.4 | 4.4 | 213,158 |
| Bronco | 100.0 | .... | 100.0 | ... | ... | ... | 44.3 | *55.4 | ... | 100.0 | ... | 100.0 | 77.0 | 4.3 | 94.7 | 100.0 | ... | 214,073 |
| Econoline | 100.0 | .... | 100.0 | ... | ... | ... | 16.4 | *83.5 | ... | 100.0 | ... | 100.0 | 83.0 | 2.0 | 95.0 | 100.0 | ... | 23,342 |
| Tot. GM Units | 3,823,107 | 123,759 | 2,559,433 | 1,266,516 | 268,574 | 3,211,694 | 524,910 | 302,535 | ... | 3,738,093 | 994,814 | 1,821,177 | 347,651 | 21,105 | 574,790 | 770,551 | 282,075 | 4,093,429 |
| % Total Output | 93.5 | 3.0 | 62.5 | 30.9 | 6.6 | 78.4 | 12.8 | 7.4 | ... | 91.3 | 24.3 | 44.5 | 8.5 | 0.5 | 14.0 | 18.8 | 6.9 | |
| Ford | 93.9 | ... | 96.4 | 4.6 | 1.0 | 84.6 | 6.6 | 1.9 | ... | 96.9 | 2.5 | 72.4 | 2.1 | ... | 3.9 | 4.6 | 18.7 | 917,028 |
| Falcon (Torino) | 80.5 | 3.7 | 23.4 | 59.7 | 15.9 | 87.1 | 2.8 | ... | ... | 77.9 | ... | 30.4 | ... | ... | 0.6 | 1.1 | 5.4 | 219,015 |
| Fairlane | 81.9 | .... | .... | 10.4 | 80.6 | 80.5 | .... | .... | .... | 23.0 | .... | .... | .... | .... | .... | .... | 5.2 | 156,614 |
| Ranchero | 66.4 | .... | .... | .... | 100.0 | 82.1 | .... | .... | .... | 7.1 | .... | .... | .... | .... | .... | .... | .... | 26,342 |
| Mustang | 74.6 | 11.2 | 25.2 | 59.8 | 15.0 | 89.1 | 4.0 | 4.6 | ... | 72.9 | ... | 35.2 | ... | ... | ... | ... | ... | 426,342 |
| Thunderbird | 100.0 | .... | 100.0 | .... | .... | 33.0 | 50.3 | 16.7 | ... | 100.0 | ... | 100.0 | 46.6 | ... | 64.6 | 83.2 | ... | 94,342 |
| Mercury | 99.9 | .... | 42.6 | 57.4 | .... | 69.3 | 20.3 | 6.6 | 10.1 | 98.2 | ... | 92.0 | 11.8 | ... | 26.6 | 26.6 | 12.5 | 148,613 |
| Montego | 96.5 | 2.9 | 13.4 | 73.6 | 13.0 | 89.6 | 4.6 | .... | ... | 98.1 | ... | 42.1 | ... | ... | 1.0 | 1.9 | 5.4 | 201,842 |
| Cougar | 99.2 | 2.8 | 100.0 | .... | .... | 77.0 | 13.8 | 7.0 | ... | 99.6 | ... | 67.6 | .... | .... | .... | 5.9 | .... | 79,158 |
| Comet | 100.0 | .... | 100.0 | .... | .... | 26.4 | 55.2 | 18.0 | 99.6 | 100.0 | .... | 100.0 | 81.4 | 3.9 | 99.1 | 100.0 | .... | 37,015 |
| Marquis | 100.0 | .... | 100.0 | .... | .... | 6.5 | 69.5 | 23.9 | 99.9 | 100.0 | .... | 100.0 | 97.9 | **3.4 | 99.6 | 100.0 | .... | 21,342 |
| Tot. Ford Units | 1,832,015 | 38,592 | 1,345,997 | 511,849 | 378,354 | 1,659,900 | 176,037 | 59,600 | 73,955 | 1,616,268 | 20,460 | 1,092,236 | 107,582 | 2,193 | 161,003 | 160,003 | 180,728 | 2,556,221 |
| % Total Output | 90.3 | 1.9 | 66.3 | 25.1 | 18.9 | 81.5 | 8.6 | 2.9 | 3.6 | 79.4 | 1.0 | 53.6 | 5.3 | 0.1 | 7.9 | 5.3 | 8.9 | |
| Fury | 98.9 | .... | 55.3 | 42.4 | 1.3 | 82.8 | 2.6 | 1.9 | ... | 98.9 | 41.3 | 20.0 | 1.5 | ... | 2.3 | 2.6 | 13.8 | 267,707 |
| Belvedere | 82.9 | 12.0 | 64.0 | 6.6 | 9.4 | 82.7 | 2.5 | 4.0 | ... | 76.7 | 9.0 | 9.8 | ... | ... | ... | 0.5 | 6.7 | 150,735 |
| Belvedere | 72.4 | 18.5 | 54.3 | 33.7 | 12.0 | 82.9 | 4.8 | 8.7 | ... | 89.9 | 6.6 | 13.2 | ... | ... | ... | 2.1 | ... | 48,439 |
| Coronet | 75.9 | 3.1 | 27.5 | ... | 72.5 | 84.0 | ... | ... | ... | 42.7 | 1.6 | 2.1 | ... | ... | ... | ... | ... | 24,557 |
| Polara | 99.7 | ... | 55.1 | 44.8 | 0.1 | 78.7 | 5.6 | 2.6 | ... | 99.4 | 58.7 | 24.4 | 3.9 | ... | 6.4 | 7.6 | 14.2 | 91,004 |
| Charger | 91.7 | 5.5 | 93.2 | 9.9 | 9.9 | 86.4 | 2.0 | 1.9 | ... | 86.3 | 11.4 | 9.9 | ... | ... | ... | 0.5 | 9.5 | 120,515 |
| Coronet | 91.3 | 7.4 | 61.4 | 33.1 | 0.5 | 80.6 | 7.2 | 10.1 | ... | 99.7 | 28.4 | 19.7 | ... | ... | ... | 4.6 | ... | 49,713 |
| Challenger | 99.9 | 2.6 | 30.3 | .... | 69.7 | 88.3 | .... | .... | .... | 97.3 | 1.6 | 1.5 | .... | .... | .... | .... | .... | 46,751 |
| Challenger | 77.1 | 12.7 | 69.0 | 29.6 | 1.4 | 81.5 | 6.5 | 7.6 | ... | 74.8 | 8.8 | 19.1 | ... | ... | ... | 3.3 | ... | 91,002 |
| Charger | 99.0 | .... | 59.4 | 9.6 | .... | 73.4 | 12.7 | 11.7 | 12.3 | 90.8 | 52.2 | 20.1 | 11.7 | ... | 27.3 | 29.1 | 9.3 | 122,777 |
| Road Runner | 100.0 | .... | 100.0 | .... | .... | 19.3 | 39.8 | 44.8 | 100.0 | 100.0 | .... | 100.0 | 75.1 | .... | 99.5 | 100.0 | .... | 21,815 |
| Tot. Chrysler Units | 1,169,435 | 5,517 | 793,535 | 400,405 | 256,461 | 1,064,971 | 57,306 | 58,617 | 34,052 | 1,040,908 | 323,637 | 213,214 | 37,623 | ... | 72,700 | 86,255 | 89,242 | 1,311,673 |
| % Total Output | 89.2 | 0.05 | 60.9 | 30.5 | 19.6 | 81.2 | 4.4 | 4.5 | 2.6 | 80.0 | 24.7 | 16.3 | 2.3 | ... | 5.6 | 6.6 | 6.8 | |
| AMX | 40.0 | 60.0 | 100.0 | .... | .... | 62.4 | 11.7 | 13.5 | ... | 69.7 | 4.3 | 82.2 | ... | ... | ... | ... | ... | 4,115 |
| Rebel | 91.5 | 2.7 | 3.9 | 42.9 | 48.0 | 54.5 | 1.1 | .... | ... | 50.4 | 16.9 | 6.0 | ... | ... | ... | ... | 9.2 | 47,015 |
| Hornet | 67.3 | .... | .... | 7.3 | 83.7 | 43.3 | .... | .... | .... | 23.4 | 2.2 | 2.0 | ... | ... | ... | ... | ... | 24,158 |
| Hornet | 99.2 | .... | 82.4 | 10.1 | 7.5 | 77.2 | 4.2 | 1.2 | ... | 80.7 | 61.9 | 12.1 | ... | ... | ... | 3.7 | 14.7 | 21,015 |
| Gremlin | 72.5 | 8.4 | .... | 70.7 | 10.7 | 71.9 | 2.7 | 2.7 | ... | 70.4 | 21.5 | 22.1 | ... | ... | ... | ... | ... | 21,015 |
| Gremlin | 2.7 | .... | .... | .... | 100.0 | 55.5 | .... | .... | .... | 11.5 | 3.0 | .... | .... | .... | .... | .... | .... | 2,342 |
| Total AMC Units | 121,195 | 6,251 | 55,240 | 56,274 | 120,785 | 143,720 | 4,318 | 2,079 | ... | 125,904 | 54,523 | 21,693 | ... | ... | ... | 2,224 | 13,373 | 240,674 |
| % Total Output | 78.0 | 2.5 | 22.8 | 23.4 | 40.8 | 50.2 | 1.8 | 0.9 | ... | 51.9 | 22.5 | 9.0 | ... | ... | ... | 0.6 | 5.5 | |
| Tot. Industry Units | 7,017,324 | 174,555 | 4,540,367 | 2,235,634 | 1,024,150 | 6,080,575 | 762,701 | 422,491 | 108,007 | 6,530,273 | 1,302,493 | 3,148,326 | 492,856 | 23,305 | 808,493 | 1,040,789 | 585,442 | 7,698,397 |
| % Total Output | 91.3 | 2.3 | 59.2 | 29.1 | 11.6 | 79.1 | 9.9 | 5.5 | 1.4 | 85.0 | 13.1 | 41.0 | 6.4 | 0.3 | 10.5 | 13.6 | 7.3 | |

Note A. Chrysler Corp. installation rates are based on cars built both in U.S. and Canada for sale in the U.S. only. '70 model output of Corvette, Camaro and Firebird did not begin until early 1970. *Cadillac and Eldorado were equipped with stereo tape as opposed to stereo tape. **Were 11 had a split bench seat that was 2-way on the passenger side and 2-way on the driver side. †Were equipped with standard front disc brakes as '70½ models. Maverick includes '69 and '70 models. Falcon is '70 model through Dec. 5, 1969. Mercury is North American industry.

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WARD'S AUTOMOTIVE REPORTS 37

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E-1353

30 WARD'S AUTOMOTIVE YEARBOOK

# Percent of Factory Installed Equipment on U.S. '70 Model Cars (Continued)

| | Bucket Seating | Vinyl Roof | White Sidewall Tires | Tinted Windshield | Tinted Windshield & Other Windows | Air Conditioning | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Column | Speed Regulating Devices | SW Luggage Rack | Reclining Front Seats | Dual Exhausts | '70 Model Year Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | ... | 36.3 | 82.9 | 6.5 | 70.4 | 71.8 | 4.5 | 13.5 | 53.5 | ... | 4.3 | 13.5 | 19.5 | 8.5 | 2.0 | 8.5 | ... | 4.6 | 831,135 |
| Corvette | 100.0 | 4.8 | 84.2 | ... | 100.0 | 38.5 | 100.0 | ... | 22.0 | 100.0 | ... | 100.0 | ... | 23.5 | ... | ... | ... | 100.0 | 17,316 |
| Chevelle | 16.9 | 38.2 | 83.1 | 1.9 | 63.8 | 45.7 | 10.9 | ... | 48.4 | ... | 25.7 | ... | 13.4 | 3.2 | 0.1 | 3.0 | ... | 17.4 | 447,645 |
| Nova | 3.9 | 18.0 | 68.5 | 1.1 | 34.0 | 14.3 | 6.2 | ... | 36.5 | ... | 12.4 | ... | 3.5 | ... | ... | ... | ... | 2.5 | 316,122 |
| Monte Carlo | 16.9 | 81.1 | 90.8 | 1.9 | 77.0 | 69.4 | 10.9 | ... | 38.8 | ... | 20.6 | 100.0 | ... | 16.2 | 0.1 | ... | ... | 11.4 | 110,970 |
| Camaro | 100.0 | 34.5 | 91.6 | ... | 57.1 | 30.9 | 15.8 | ... | 61.5 | ... | 12.2 | ... | 12.4 | 5.4 | ... | ... | ... | 17.0 | 224,931 |
| Firebird | ... | 45.7 | 92.5 | 22.4 | 63.3 | 82.1 | 7.2 | 33.7 | 56.1 | ... | 5.3 | 39.5 | 14.4 | 13.2 | 8.3 | 8.3 | ... | 6.2 | 230,476 |
| Grand Prix | 99.1 | 87.6 | 95.4 | 11.3 | 84.4 | 91.2 | 9.7 | 35.9 | 9.0 | ... | 59.1 | 100.0 | ... | 50.1 | 9.7 | ... | 1.8 | 100.0 | 66,780 |
| Tempest | 42.8 | 42.5 | 85.2 | 32.7 | 44.5 | 57.5 | 9.7 | ... | 65.1 | ... | 23.4 | ... | 20.9 | 2.4 | 1.0 | 2.1 | 0.3 | 13.0 | 210,439 |
| Firebird | 100.0 | 24.0 | 91.7 | 31.2 | 41.0 | 45.9 | 10.8 | 21.1 | 28.6 | 6.6 | 38.5 | ... | 17.4 | 5.3 | ... | ... | ... | 22.4 | 49,738 |
| Catalina | 1.0 | 71.0 | 95.0 | 20.0 | 74.0 | 86.0 | 7.0 | 77.0 | 23.0 | ... | ... | 37.0 | 18.0 | 25.0 | 9.0 | ... | ... | ... | 459,765 |
| Tornado | 7.0 | 31.0 | 55.0 | 7.0 | 91.0 | 97.0 | ... | ... | 62.0 | ... | ... | 100.0 | ... | 73.0 | 29.0 | ... | ... | 100.0 | 25,375 |
| Ross | 25.0 | 45.0 | 83.0 | 28.0 | 55.0 | 67.0 | 10.0 | ... | 69.0 | ... | 18.0 | ... | 20.0 | 6.0 | 2.0 | 7.0 | ... | 18.0 | 515,273 |
| Buick | 0.4 | 65.3 | 95.5 | 19.0 | 76.0 | 85.6 | 8.0 | 72.8 | 21.8 | ... | 3.4 | 37.3 | 30.7 | 27.6 | 13.8 | 5.0 | ... | 6.1 | 422,744 |
| Riviera | 27.7 | 87.5 | 95.7 | 6.7 | 91.5 | 96.9 | 18.1 | 38.3 | 4.2 | ... | 57.6 | 100.0 | ... | 100.0 | 25.7 | ... | ... | 100.0 | 37,035 |
| Electra | 8.8 | 48.6 | 89.2 | 35.7 | 47.3 | 63.2 | 5.3 | ... | 73.6 | ... | 14.3 | ... | 19.7 | 7.5 | 1.1 | 2.6 | ... | 11.0 | 265,431 |
| Oldsmobile | ... | 78.7 | 95.3 | ... | 98.3 | 98.4 | 10.9 | 100.0 | ... | ... | ... | 100.0 | ... | 63.3 | 20.2 | ... | ... | ... | 214,903 |
| Estate | 1.9 | 94.0 | 96.2 | ... | 98.5 | 99.7 | ... | 100.0 | ... | ... | ... | 100.0 | ... | 87.2 | 37.5 | ... | ... | ... | 23,842 |
| Tot. GM Units | 571,635 | 1,970,765 | 3,579,767 | 533,647 | 2,817,025 | 2,725,282 | 342,831 | 1,030,536 | 1,811,944 | 20,533 | 483,521 | 1,025,383 | 636,351 | 525,948 | 208,957 | 165,477 | 1,824 | 498,789 | 4,036,419 |
| % Tot. Output | 14.0 | 48.1 | 87.4 | 13.2 | 68.8 | 66.5 | 8.3 | 25.2 | 44.2 | 0.5 | 11.8 | 25.0 | 15.5 | 12.8 | 5.1 | 4.0 | .004 | 12.2 | |
| Ford | 1.2 | 34.9 | 78.1 | 7.3 | 64.6 | 71.7 | 3.8 | 25.8 | 40.5 | ... | ... | 21.6 | 11.2 | 3.3 | 2.2 | 13.3 | 1.7 | 1.4 | 807,328 |
| Fairlane (Torino) | 9.0 | 21.0 | 75.5 | 2.0 | 43.7 | 41.6 | 6.4 | 2.6 | 45.8 | ... | 2.7 | ... | 8.9 | ... | ... | 3.9 | ... | ... | 326,710 |
| Falcon | ... | ... | 61.5 | 0.2 | 17.6 | 9.6 | ... | ... | 43.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 55,484 |
| Maverick | ... | 6.3 | 70.5 | ... | 31.5 | 18.9 | ... | ... | 73.9 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 265,934 |
| Mustang | 100.0 | 19.1 | 78.9 | 2.6 | 37.9 | 28.2 | 10.6 | 32.3 | 49.7 | ... | 4.1 | 28.6 | 4.7 | 2.5 | ... | ... | ... | 14.2 | 121,727 |
| Thunderbird | 37.4 | 69.6 | 96.7 | ... | 93.8 | 93.7 | 9.4 | 75.4 | 24.6 | ... | ... | 100.0 | ... | 71.5 | 20.7 | ... | 14.1 | 100.0 | 91,364 |
| Mercury | 1.2 | 61.9 | 92.8 | 3.5 | 81.8 | 83.8 | 5.5 | 50.9 | 32.1 | ... | 1.0 | 55.6 | 6.0 | 20.4 | 9.8 | 16.2 | 8.1 | ... | 169,503 |
| Montego | 11.9 | 37.4 | 79.6 | 5.2 | 47.1 | 49.5 | 5.3 | 14.7 | 51.2 | ... | 2.7 | ... | 12.6 | ... | ... | 4.6 | ... | 11.1 | 103,672 |
| Cougar | 100.0 | 69.7 | 96.6 | ... | 63.9 | 61.7 | 5.1 | 30.9 | 57.7 | ... | 3.3 | 30.9 | 9.8 | 12.1 | ... | ... | ... | 11.9 | 72,303 |
| Lincoln | ... | 91.5 | 98.4 | ... | 99.6 | 98.6 | 14.5 | 79.9 | 20.1 | ... | ... | 100.0 | ... | 60.4 | 40.3 | ... | 21.6 | ... | 37,035 |
| Mark III | ... | 100.0 | 99.6 | ... | 99.9 | 90.9 | ... | 17.9 | 100.0 | ... | ... | 100.0 | ... | 33.9 | 55.0 | ... | 34.7 | 100.0 | 21,432 |
| Tot. Ford Units | 335,400 | 651,624 | 1,633,079 | 81,052 | 1,063,003 | 1,146,476 | 103,391 | 480,925 | 1,004,438 | ... | 23,250 | 443,291 | 157,794 | 147,215 | 76,070 | 149,243 | 46,300 | 130,840 | 2,035,211 |
| % Tot. Output | 16.5 | 32.5 | 80.2 | 4.0 | 52.2 | 56.3 | 5.1 | 23.8 | 49.3 | ... | 1.1 | 21.8 | 7.7 | 7.2 | 3.7 | 7.3 | 2.3 | 6.4 | |
| Fury | 3.2 | 31.0 | 67.4 | 12.9 | 57.7 | 60.3 | 6.9 | ... | 70.1 | 0.8 | 1.2 | ... | 22.6 | 1.4 | 2.1 | 5.8 | 2.4 | 7.9 | 257,787 |
| Belvedere | 13.4 | 26.5 | 79.4 | 28.9 | 32.8 | 35.4 | 16.8 | 8.2 | 44.9 | ... | 22.6 | ... | 9.6 | ... | 0.4 | 4.2 | ... | 32.4 | 122,735 |
| Satellite | 82.6 | 43.5 | 76.7 | 29.5 | 28.2 | 22.0 | 29.4 | ... | 43.9 | ... | 42.6 | ... | 27.7 | ... | 0.6 | ... | ... | 39.7 | 59,429 |
| Valiant | 9.6 | 14.7 | 67.6 | 21.1 | 13.9 | 18.8 | 6.4 | ... | 45.4 | 9.2 | 2.7 | ... | ... | ... | ... | ... | ... | 9.2 | 241,697 |
| Polara | 1.8 | 45.0 | 90.8 | 13.5 | 74.3 | 73.2 | 7.4 | 13.8 | 78.1 | ... | 1.3 | ... | 37.1 | 4.1 | 7.1 | 9.1 | 6.4 | 5.4 | 91,804 |
| Coronet | 12.7 | 25.4 | 80.3 | 22.9 | 42.3 | 47.0 | 10.6 | 10.4 | 60.1 | ... | 12.0 | ... | 0.8 | ... | 0.9 | 5.9 | ... | 16.8 | 121,515 |
| Charger | 78.5 | 85.1 | 95.6 | 21.6 | 55.5 | 56.9 | 18.8 | ... | 64.0 | ... | 33.0 | 59.3 | 11.2 | ... | 2.6 | ... | ... | 37.8 | 49,768 |
| GTX | 2.3 | 62.4 | 81.7 | 22.8 | 20.2 | 28.7 | 4.8 | ... | 77.7 | ... | 3.6 | ... | ... | ... | ... | ... | ... | 6.1 | 46,751 |
| Challenger | 94.3 | 69.2 | 92.8 | 28.5 | 35.8 | 34.8 | 22.4 | ... | 52.7 | ... | 36.2 | 24.0 | 10.3 | ... | 1.2 | ... | ... | 38.5 | 85,032 |
| Cuda | 9.2 | 57.7 | 93.9 | 10.6 | 82.5 | 84.9 | 9.4 | 91.3 | 6.7 | ... | 2.0 | 20.0 | 22.0 | 10.4 | 15.0 | 7.3 | 18.2 | 53.7 | 109,777 |
| Imperial | 9.5 | 98.5 | 98.7 | ... | 99.3 | 99.3 | 29.4 | 100.0 | ... | ... | ... | 100.0 | ... | 69.1 | 66.6 | ... | 69.4 | ... | 11,515 |
| Chrysler Units | 257,753 | 509,670 | 1,042,187 | 263,809 | 604,206 | 665,200 | 150,769 | 215,305 | 662,721 | 24,365 | 145,814 | 97,411 | 189,389 | 34,324 | 51,420 | 53,633 | 54,765 | 269,805 | 1,511,073 |
| % Tot. Output | 19.7 | 38.9 | 79.5 | 20.1 | 46.1 | 50.8 | 11.5 | 16.4 | 50.5 | 1.9 | 11.1 | 7.4 | 14.4 | 2.6 | 3.9 | 4.1 | 4.2 | 20.3 | |
| AMC | 100.0 | ... | ... | 21.6 | 41.2 | 25.7 | 82.6 | ... | ... | 100.0 | ... | ... | 55.1 | 20.0 | ... | ... | ... | 100.0 | 4,115 |
| Rebel | 8.9 | 11.8 | 49.4 | 13.1 | 22.4 | 18.0 | 16.2 | 55.7 | 40.4 | 3.9 | ... | ... | 21.8 | 2.3 | 0.5 | 13.8 | 33.3 | 4.7 | 48,126 |
| Rebel | ... | 7.1 | 40.6 | 10.4 | 15.2 | 13.6 | 2.4 | 51.6 | 48.4 | ... | ... | ... | 7.8 | ... | ... | ... | 17.7 | ... | 73,943 |
| Ambassador | 6.5 | 23.6 | 81.0 | 24.7 | 59.7 | 86.3 | 12.6 | 55.0 | 5.0 | ... | ... | 56.1 | 9.5 | 13.2 | 7.2 | 23.3 | 61.9 | 7.3 | 54,641 |
| Javelin | 100.0 | 38.4 | 97.9 | 23.7 | 19.7 | 24.9 | 9.9 | 69.2 | 13.4 | ... | 17.3 | ... | 22.4 | 6.2 | ... | ... | 0.0 | 21.5 | 30,634 |
| AMX | 15.2 | ... | 60.9 | 6.7 | 14.2 | 9.5 | 3.4 | 51.9 | 48.1 | ... | ... | ... | ... | ... | ... | ... | 0.0 | ... | 58,000 |
| Tot. AMC Units | 40,265 | 36,179 | 135,379 | 38,166 | 67,564 | 83,423 | 24,603 | 156,497 | 74,925 | 6,052 | 5,210 | 33,696 | 33,303 | 11,741 | 4,572 | 20,629 | 27,765 | 17,203 | 242,609 |
| % Tot. Output | 20.0 | 14.9 | 55.8 | 15.7 | 27.8 | 34.4 | 10.1 | 64.5 | 30.9 | 2.5 | 2.1 | 13.9 | 13.8 | 4.8 | 1.9 | 8.6 | 27.9 | 7.1 | |
| Total Industry Units | 1,213,053 | 3,168,268 | 6,390,412 | 922,674 | 4,552,797 | 4,620,790 | 621,674 | 1,883,313 | 3,554,028 | 50,950 | 657,795 | 1,599,741 | 1,016,374 | 719,236 | 341,319 | 369,232 | 130,854 | 915,837 | 7,855,357 |
| % Tot. Output | 15.8 | 41.6 | 83.1 | 12.0 | 59.2 | 60.1 | 8.1 | 24.6 | 46.2 | 0.6 | 8.6 | 20.8 | 13.2 | 9.4 | 4.4 | 5.1 | 2.2 | 11.9 | |

Note: All Chrysler Corp. installation rates are based on cars built both in U.S. and Canada for sale in the U.S. only. '70 model output of Corvette, Camaro and Firebird did not begin until early 1970. Maverick includes '69 and '70 models. Falcons '70 made through Dec. 3, 1969. Mercury's 169,503 is both American production.

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# U.S. Car Factory-Installed Equipment Rates (%)—1971 Model Year

| Models | Automatic Transmission | 4-Speed Manual Transmission | V-8 Engine Standard | V-8 Engine Optional | 6 Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Tape | Power Antenna | Power Steering | Power 4-Wheel Drum Brakes | Front Wheel Disc Standard | Front Wheel Disc Optional | Power Door Locks | 2-Way Power Seats | 4- or 6-Way Power Seats | Power Windows | Total Cars |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 93.1 | ... | 59.6 | 38.9 | 1.5 | 84.2 | 10.5 | 5.4 | ... | 99.8 | ... | 100.0 | ... | 3.7 | ... | 3.3 | 9.4 | 670,659 |
| Corvette | 46.1 | 50.9 | 96.8 | 3.2 | ... | ... | 96.7 | 15.1 | ... | 82.1 | ... | ... | 69.2 | ... | ... | ... | 23.4 | 21,536 |
| Chevelle | 53.7 | 3.2 | 49.3 | 44.1 | 5.6 | 83.5 | 6.4 | 4.1 | ... | 90.5 | 32.9 | ... | 22.2 | 1.2 | ... | ... | 7.5 | 351,159 |
| Nova | 81.7 | 2.0 | 58.7 | 12.6 | 48.7 | 61.1 | 1.9 | ... | ... | 61.6 | 10.5 | ... | 7.4 | ... | ... | ... | ... | 196,181 |
| Monte Carlo | 99.4 | 0.3 | 56.3 | 44.7 | ... | 78.7 | 21.1 | 15.0 | ... | 99.3 | ... | 100.0 | ... | 1.2 | ... | 2.4 | 8.8 | 130,317 |
| Camaro | 73.4 | 9.3 | 49.0 | 41.2 | 9.8 | 83.6 | 11.5 | ... | ... | 89.3 | ... | ... | 26.3 | ... | ... | ... | ... | 243,163 |
| Vega | 43.1 | 33.1 | ... | ... | ... | 59.0 | 3.7 | ... | ... | 0.5 | ... | 100.0 | ... | ... | ... | ... | ... | 268,245 |
| Pontiac | 99.9 | ... | 100.0 | ... | ... | 74.1 | 12.7 | 10.0 | ... | 100.0 | ... | 100.0 | ... | 8.7 | 0.2 | 10.1 | 22.4 | 470,915 |
| Grand Prix | 99.8 | 0.1 | 100.0 | ... | ... | 46.1 | 25.0 | 26.5 | ... | 100.0 | ... | 100.0 | ... | 9.4 | ... | 16.8 | 53.3 | 109,632 |
| LeMans | 93.5 | 2.1 | 6.4 | 85.7 | 7.9 | 97.6 | 5.3 | 3.2 | ... | 54.7 | 21.7 | 4.4 | 23.0 | 0.8 | ... | 0.9 | 5.3 | 151,634 |
| Firebird | 87.8 | 0.0 | 59.7 | 37.7 | 5.6 | 79.0 | 9.8 | 8.4 | ... | 92.0 | ... | 4.0 | 54.5 | 1.2 | ... | ... | 4.5 | 82,274 |
| Ventura II | 87.4 | ... | ... | 40.8 | 53.2 | 92.0 | 0.9 | ... | ... | 51.7 | 9.5 | ... | 3.1 | ... | ... | ... | ... | 52,242 |
| Oldsmobile | 100.0 | ... | 100.0 | ... | ... | 73.1 | ... | 24.2 | ... | 100.0 | ... | 100.0 | ... | 13.7 | 5.2 | 38.3 | 42.9 | 291,193 |
| Toronado | 100.0 | ... | 100.0 | ... | ... | 37.3 | ... | 09.6 | ... | 100.0 | ... | 100.0 | ... | 40.3 | ... | 81.2 | 95.5 | 24,441 |
| F-85 | 99.1 | 0.9 | 58.8 | ... | 1.2 | 86.0 | ... | 7.2 | ... | 59.7 | 40.8 | 13.9 | 28.4 | 2.3 | ... | 4.6 | 12.2 | 244,251 |
| Eight | 100.0 | ... | 71.6 | 15.4 | ... | 63.6 | 15.7 | 13.2 | ... | 100.0 | ... | 100.0 | ... | 21.0 | 0.2 | 25.6 | 51.5 | 331,253 |
| Riviera | 100.0 | ... | 100.0 | ... | ... | 30.7 | 16.8 | 52.1 | ... | 100.0 | ... | 100.0 | ... | 37.4 | ... | 79.1 | 94.3 | 80,179 |
| Starfire | 59.0 | 0.4 | 28.1 | 09.6 | 2.3 | 87.1 | 9.2 | ... | ... | 97.7 | 43.8 | 6.8 | 10.6 | 1.7 | ... | 1.5 | 10.4 | 110,179 |
| Cutlass | 100.0 | ... | 100.0 | ... | ... | ... | 25.1 | 02.2 | ... | 100.0 | ... | 100.0 | ... | 21.9 | 2.7 | 26.1 | 44.9 | 341,179 |
| Delmont | 100.0 | ... | 100.0 | ... | ... | ... | 11.1 | 88.8 | ... | 100.0 | ... | 100.0 | ... | 23.9 | 2.4 | 27.6 | 44.3 | 341,179 |
| Total GM Units | 3,290,099 | 136,053 | 2,148,537 | 959,005 | 186,217 | 2,687,081 | 360,704 | 446,453 | — | 3,121,737 | 357,252 | 2,511,767 | 312,023 | 369,616 | 25,402 | 513,679 | 822,283 | 3,556,183 |
| % Total Output | 92.5 | 3.8 | 60.4 | 27.0 | 5.2 | 75.6 | 10.1 | 12.6 | — | 87.8 | 10.0 | 70.6 | 8.8 | 10.3 | 0.7 | 14.4 | 23.1 | — |
| Falcon | 99.5 | ... | 63.8 | 35.7 | 0.5 | 82.5 | 9.0 | 2.2 | ... | 90.0 | 1.8 | 3.8 | 25.4 | 3.0 | ... | 4.6 | 11.3 | 314,455 |
| Torino | 99.0 | 1.1 | 100.9 | 59.2 | 8.3 | 89.9 | 2.5 | ... | ... | 90.4 | ... | 5.6 | 27.5 | ... | ... | 0.6 | 12.3 | 341,455 |
| Maverick | 76.3 | ... | ... | 12.0 | 88.0 | 87.5 | ... | ... | ... | 28.7 | ... | ... | ... | ... | ... | ... | ... | 217,455 |
| Mustang | 83.9 | 5.3 | 25.4 | 64.8 | 9.8 | 83.7 | 9.1 | 5.6 | ... | 85.7 | ... | 1.0 | 39.9 | ... | ... | ... | 1.5 | 217,455 |
| Thunderbird | 100.0 | ... | 100.0 | ... | ... | 26.9 | 59.6 | 13.5 | 30.0 | 100.0 | ... | 100.0 | ... | 40.3 | ... | 72.0 | 89.5 | 87,455 |
| Pinto | 47.1 | 52.9 | ... | ... | ... | 80.4 | ... | ... | ... | ... | ... | ... | 30.0 | ... | ... | ... | ... | 276,224 |
| Mercury | 100.0 | ... | 59.6 | 40.4 | ... | 62.2 | 25.3 | 7.7 | 14.8 | 100.0 | ... | 100.0 | ... | 18.8 | ... | 32.3 | 47.5 | 151,455 |
| Montego | 99.1 | 0.8 | 2.3 | 89.2 | 8.5 | 92.6 | 3.9 | ... | ... | 94.5 | ... | ... | 43.5 | ... | ... | 0.8 | 8.3 | 151,455 |
| Cougar | 96.9 | 1.0 | 87.9 | 12.1 | ... | 68.7 | 20.8 | 9.0 | ... | 96.5 | ... | ... | 79.7 | ... | ... | 4.6 | 9.3 | 151,455 |
| Comet | 81.0 | ... | ... | 38.1 | 61.9 | 87.0 | ... | ... | ... | 48.3 | ... | ... | ... | ... | ... | ... | ... | 151,455 |
| Lincoln | 100.0 | ... | 100.0 | ... | ... | 47.1 | 66.7 | 15.9 | 99.7 | 100.0 | ... | 100.0 | ... | 59.4 | 3.2 | 90.2 | 100.0 | 84,455 |
| Mark III | 100.0 | ... | 100.0 | ... | ... | 4.2 | 74.7 | 21.0 | 99.0 | 100.0 | ... | 100.0 | ... | 50.7 | 3.1 | 91.9 | 100.0 | 84,455 |
| Total Ford Units | 1,897,270 | 147,713 | 791,979 | 791,542 | 231,900 | 1,689,027 | 375,359 | 58,025 | 77,503 | 1,506,432 | 14,654 | 640,819 | 472,233 | 120,926 | 2,191 | 173,700 | 455,455 | 2,244,877 |
| % Total Output | 69.0 | 7.0 | 37.3 | 37.3 | 10.9 | 79.6 | 17.7 | 2.7 | 3.7 | 75.3 | 0.7 | 29.9 | 22.0 | 5.7 | 0.1 | 8.2 | 21.5 | — |
| Fully | 99.5 | ... | 33.0 | 65.8 | 1.2 | 82.0 | ... | 3.9 | ... | 97.1 | ... | 0.1 | 77.3 | 1.6 | ... | 1.9 | 6.1 | 161,000 |
| Sportsman | 93.1 | 2.6 | 82.5 | 9.6 | 7.9 | 86.0 | ... | 4.6 | ... | 90.1 | 12.0 | ... | 22.1 | ... | ... | ... | 7.9 | 161,000 |
| Fairbourne | 78.7 | 12.3 | 62.3 | 27.7 | 10.0 | 81.7 | ... | 15.3 | ... | 71.3 | 6.0 | ... | 24.7 | ... | ... | ... | 2.6 | 161,000 |
| Custom | 82.6 | 1.1 | 22.9 | ... | 74.1 | 86.4 | ... | 0.4 | ... | 57.3 | 1.6 | ... | 2.4 | ... | ... | ... | ... | 161,000 |
| Polara | 99.8 | ... | 99.9 | 63.0 | 0.1 | 89.2 | ... | 9.8 | ... | 90.9 | ... | 7.2 | 76.4 | 3.5 | ... | 9.2 | 12.3 | 161,000 |
| Coronet/Charger | 99.6 | 1.1 | 77.5 | 17.2 | 5.3 | 88.5 | ... | 5.6 | ... | 94.5 | 12.7 | ... | 23.4 | ... | ... | ... | 12.3 | 161,000 |
| Challenger | 88.7 | 5.3 | 76.5 | 15.8 | 6.7 | 89.0 | ... | 11.7 | ... | 85.2 | 5.9 | ... | 15.1 | ... | ... | ... | 4.4 | 161,000 |
| Dart | 91.1 | 1.0 | 31.3 | ... | 68.7 | 90.0 | ... | 0.2 | ... | 73.0 | 1.7 | ... | 2.4 | ... | ... | ... | ... | 161,000 |
| Chrysler | 99.9 | ... | 88.8 | 11.2 | ... | 71.6 | 8.8 | 17.9 | 8.1 | 99.9 | ... | 62.2 | 30.8 | 19.1 | ... | 23.4 | 33.4 | 174,000 |
| Imperial | 100.0 | ... | 100.0 | ... | ... | ... | 19.6 | 80.1 | ... | 100.0 | ... | 100.0 | ... | 81.5 | ... | 97.2 | 100.0 | 174,000 |
| Total Chrysler Units | 1,180,292 | 12,253 | 646,076 | 318,474 | 239,625 | 1,062,794 | 17,597 | 80,540 | 14,318 | 1,079,831 | 26,936 | 123,235 | 430,612 | 39,020 | — | 72,243 | 191,324 | 1,218,219 |
| % Total Output | 64.0 | 1.0 | 51.4 | 25.4 | 23.1 | 84.6 | 1.4 | 6.4 | 1.1 | 80.0 | 2.9 | 10.2 | 34.9 | 3.1 | — | 5.8 | 15.2 | — |
| Rambler | 98.5 | 0.1 | ... | 64.9 | 30.5 | 67.5 | 1.0 | 0.1 | ... | 97.0 | 12.1 | ... | 9.4 | ... | ... | ... | 11.5 | 35,000 |
| Hornet | 00.2 | 0.5 | 1.0 | 5.2 | 70.5 | 42.3 | ... | ... | ... | 26.5 | 4.9 | ... | 2 | ... | ... | ... | ... | 4,000 |
| Ambassador | 100.0 | ... | 81.0 | 14.6 | 1.4 | 75.5 | 5.6 | 1.0 | ... | 97.0 | 58.7 | ... | 25.7 | ... | ... | ... | 23.9 | 4,000 |
| Javelin/AMX | 53.4 | 2.9 | 7.1 | 74.5 | 18.1 | 74.2 | 4.9 | 3.2 | ... | 70.5 | 10.7 | ... | 21.9 | ... | ... | ... | ... | 39,000 |
| Gremlin | 47.0 | ... | ... | ... | 100.0 | 55.2 | ... | ... | ... | 13.7 | 1.3 | ... | ... | ... | ... | ... | ... | 39,000 |
| Total AMC Units | 104,929 | 1,559 | 37,537 | 61,306 | 124,701 | 142,978 | 4,256 | 1,420 | — | 120,903 | 35,642 | — | 20,013 | — | — | — | 14,914 | 240,000 |
| % Total Output | 91.1 | 0.9 | 10.5 | 25.1 | 51.0 | 59.4 | 1.8 | 0.6 | — | 51.5 | 15.2 | — | 11.9 | — | — | — | 6.4 | — |
| TOTAL INDUSTRY UNITS | 6,542,000 | 297,618 | 3,624,429 | 2,130,617 | 830,693 | 5,672,100 | 758,019 | 526,438 | 77,503 | 5,924,903 | 418,484 | 3,200,824 | 1,297,707 | 529,533 | 27,593 | 759,422 | 1,483,976 | *7,240,000 |
| % TOTAL OUTPUT | 91.1 | 4.1 | 50.5 | 29.7 | 11.6 | 79.0 | 10.6 | 7.3 | 1.1 | 82.5 | 6.2 | 44.6 | 17.5 | 7.3 | 0.4 | 10.6 | 21.7 | — |

Note: All Chrysler Corp. installation rates are based on cars built in U.S. and Canada for sale in U.S. Ford Division rates exclude cars built in U.S. for sale in Canada. Mercury installation rates are based on combined U.S. and Canada output. The Stereo Tape item includes Stereo Radio and Stereo Radio/Tape, but varies by car lines. *Includes 21,056 Ford Club Wagons for which installation rates are not figured.

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# U.S. Car Factory-Installed Equipment Rates (%)—1971 Model Year (continued)

| Models | Bucket Seats | Vinyl Roof | Whitewall Tires | Tinted Windshield | Tinted Windshield & Windows | Air Conditioner Automatic Temp. Control | Air Conditioner Manual Temp. Control | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Electric Clock | Movable Steering Column | Speed Regulating Device | Reclining Front Seat | Dual Exhausts | Total Output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | | 41.8 | 82.3 | 4.5 | 80.4 | 2.3 | 29.9 | 3.9 | 12.7 | 62.5 | | | 25.3 | 12.2 | 3.5 | | | |
| Corvette | 100.0 | 3.8 | 81.9 | | 100.0 | | 52.7 | 100.0 | | 13.8 | 100.0 | | 100.0 | 37.3 | | | 10.5 | |
| Chevelle | 10.3 | 35.5 | 81.8 | 4.4 | 77.9 | | 55.3 | 5.5 | | 54.0 | | 24.0 | 1 | 4.1 | 1.0 | | 4.2 | |
| Nova | 3.3 | 15.4 | 69.7 | | 34.7 | | 19.7 | 3.7 | | 33.5 | | 14.0 | 3.0 | | | | 3.6 | |
| Monte Carlo | 10.3 | 79.0 | 99.8 | 1.4 | 73.9 | | 87.4 | 6.5 | | 33.5 | | 37.0 | 100.0 | 21.2 | 1.0 | | 5.2 | |
| Camaro | 100.0 | 33.4 | 99.2 | 0.7 | 58.7 | | 27.1 | 10.3 | | 42.9 | | 36.4 | 9.0 | 7.3 | | | 12.3 | |
| Vette | 100.0 | | 60.3 | | 31.4 | | 14.4 | 3.9 | | | | | 4.2 | | | | | |
| Pontiac | | 54.2 | 91.2 | 20.3 | 72.2 | 4.7 | 80.2 | 6.0 | 46.0 | 50.1 | | 5.6 | 55.0 | 17.0 | 8.2 | | 5.3 | |
| Grand Prix | 91.7 | 87.7 | 99.5 | 10.5 | 86.4 | 6.1 | 83.1 | 7.5 | 30.9 | | | 69.1 | 100.0 | 34.0 | 10.9 | | 14.5 | |
| LeMans | 29.4 | 33.7 | 83.8 | 33.8 | 42.5 | | 60.7 | 5.3 | | 61.4 | | 23.0 | 18.9 | 2.1 | 0.7 | | 10.7 | |
| Firebird | 100.0 | 31.5 | 69.1 | 30.1 | 45.6 | | 57.4 | 10.9 | 17.4 | 20.1 | 4.0 | 45.7 | 11.6 | 5.7 | | | 4.7 | |
| Ventura II | 4.9 | 8.9 | 81.5 | | 9.3 | | 22.3 | 0.9 | | 63.5 | | 5.4 | 2.1 | | | | | |
| Oldsmobile | | 22.9 | 95.3 | 15.6 | 78.5 | 8.7 | 81.3 | 6.6 | 41.7 | 15.7 | | 1.5 | 55.0 | 30.8 | 12.5 | | 2.1 | |
| Toronado | | 93.5 | 99.3 | 5.9 | 99.4 | 29.2 | 3 | | 100.0 | | | | 100.0 | 74.5 | 54.6 | | 10.3 | |
| Tornado | | 93.5 | 99.9 | 27.3 | 97.5 | | 73.0 | 5.5 | 2.1 | 71.4 | | 19.3 | 17.5 | 5.5 | 1.7 | | 4.7 | |
| Cutlass | 19.2 | 57.0 | | | | | | | | | | | | | | | | |
| Buick | | 70.6 | 96.3 | 15.1 | 80.8 | 6.1 | 84.2 | 7.7 | 31.6 | 23.1 | | 2.8 | 70.9 | 35.8 | 18.2 | | 3.3 | |
| Riviera | 28.1 | 75.1 | 98.6 | 7.4 | 96.7 | 12.7 | 85.5 | 18.8 | 36.7 | 7.7 | | 55.6 | 100.0 | 100.0 | 32.2 | | 10.5 | |
| Skylark | 6.1 | 47.0 | 90.9 | 35.0 | 48.7 | | 65.4 | 4.2 | | 83.0 | | 7.1 | 8.1 | 8.1 | 1.2 | | | |
| Century | | | | | | | | | | | | | 100.0 | 55.5 | 28.5 | | | |
| Cadillac | | 83.0 | 99.4 | | 99.4 | 93.4 | | 9.8 | 100.0 | | | | 97.9 | 97.9 | 44.4 | | | |
| Eldorado | | 77.3 | 99.4 | | 99.5 | 99.5 | | | 100.0 | | | | | | | | | |
| Total GM Units | 571,134 | 1,672,752 | 2,974,036 | 393,433 | 2,275,977 | 272,756 | 2,136,591 | 213,017 | 850,013 | 1,425,503 | 23,622 | 364,775 | 1,320,102 | 604,722 | 226,703 | — | 277,412 | 3,552,213 |
| % Total Output | 16.1 | 47.0 | 83.6 | 11.1 | 64.0 | 7.7 | 60.1 | 6.0 | 23.9 | 40.1 | 0.7 | 10.3 | 37.4 | 17.0 | 6.7 | — | 7.8 | |
| Ford | 0.5 | 47.3 | 81.2 | 6.2 | | 2.3 | 53.1 | 3.3 | 24.7 | 51.4 | | 4.3 | 55.9 | 4.5 | 3.4 | 2.3 | 2.1 | |
| Torino | 3.4 | 29.6 | 82.4 | 2.6 | 46.3 | | 50.3 | 6.4 | 3.9 | 23.3 | | 1.1 | 5.8 | | | | 3.4 | |
| Maverick | 7.4 | 10.11 | 78.2 | | 34.7 | | 22.1 | | | 65.3 | | | 0.4 | | | | | |
| Mustang | 100.0 | 27.0 | 82.4 | 1.9 | 45.8 | | 40.5 | 5.9 | 26.7 | 57.4 | | 2.7 | 25.9 | 3.2 | | | 14.5 | |
| Thunderbird | 22.6 | 94.0 | 99.5 | | 97.0 | 24.2 | 71.9 | 8.7 | 87.8 | 12.2 | | | 100.0 | 65.7 | 27.1 | 18.2 | 100.0 | |
| Pinto | 100.0 | 5.4 | 67.6 | | 27.5 | | 10.7 | | | 74.2 | | | 7.5 | | | | | |
| Mercury | | 70.8 | 95.0 | 1.0 | 87.4 | 22.4 | 67.6 | 7.3 | 71.0 | 19.1 | | | 70.3 | 23.5 | 16.1 | 6.5 | | |
| Montego | 9.4 | 46.9 | 81.9 | 3.6 | 56.2 | | 58.3 | 2.0 | 17.4 | 63.3 | | | 9.4 | | | | 4.7 | |
| Montclair | | 75.0 | 96.2 | 3.6 | 74.3 | | 75.0 | 2.6 | 47.0 | 46.0 | | 3.5 | 55.5 | 17.0 | | | 12.1 | |
| Cougar | 100.0 | 17.0 | 67.4 | 4.2 | 25.0 | | 24.6 | | | 61.8 | | | | | | | | |
| Comet | 15.4 | | | | | | | | | | | | | | | | | |
| Lincoln | | 91.5 | 99.7 | | 100.0 | 97.3 | 2.7 | 12.3 | 53.1 | 16.9 | | | 100.0 | 70.1 | 45.0 | 23.1 | | |
| Versailles | | 33.8 | 93.8 | | 100.0 | 100.0 | | 15.6 | 100.0 | | | | 100.0 | 85.0 | 61.7 | 25.3 | 100.0 | |
| Total Ford Units | 523,260 | 781,135 | 1,722,609 | 70,893 | 1,258,033 | 117,825 | 1,160,319 | 80,907 | 437,472 | 1,008,355 | — | 60,019 | 747,603 | 162,511 | 93,023 | 48,624 | 125,855 | 2,241,207 |
| % Total Output | 26.7 | 39.9 | 88.2 | 3.3 | 59.3 | 5.6 | 55.7 | 3.8 | 23.0 | 50.4 | — | 2.9 | 35.3 | 7.7 | 4.4 | 2.3 | 6.1 | — |
| Fury | 1.9 | 40.0 | 90.2 | 9.2 | 76.8 | | 82.9 | 5.7 | | 90.7 | 0.1 | 0.5 | 69.2 | 5.2 | 2.5 | 2.3 | 5.5 | |
| Satellite | 11.1 | 32.0 | 70.3 | 20.8 | 47.9 | | 56.4 | 8.3 | 12.6 | 55.0 | | 11.2 | 12.1 | 0.4 | 0.8 | | 2.2 | |
| Sebring | 82.0 | 45.6 | 81.2 | 22.7 | 37.4 | | 29.6 | 22.1 | | 45.3 | | 41.3 | 23.3 | | | | 4.3 | |
| Barracuda | 5.6 | 29.0 | 74.3 | 18.1 | 20.4 | | 25.6 | 3.5 | | 61.6 | | 5.0 | | | | | | |
| Valiant | | | | | | | | | | | | | | | | | | |
| Polara | 0.9 | 60.8 | 87.8 | 6.4 | 83.2 | | 67.9 | 6.5 | 7.2 | 81.1 | | 1.3 | 74.2 | 3.7 | 15.5 | 5.0 | 8.5 | |
| Coronet/Charger | 16.5 | 33.8 | 83.5 | 15.3 | 52.4 | | 69.6 | 7.0 | 15.5 | 59.0 | | 11.0 | 22.3 | 0.8 | 1.8 | | 10.3 | |
| Challenger | 9.4 | 66.5 | 92.6 | 21.3 | 61.5 | | 69.2 | 11.6 | | 50.5 | | 22.1 | 100.0 | | | | 21.6 | |
| Charger | 4.9 | 41.8 | 83.3 | 21.1 | 24.0 | | 38.2 | 3.6 | | 75.0 | | 4.3 | | | | | | |
| GTX | | | | | | | | | | | | | | | | | | |
| Imperial | 7.0 | 62.5 | 94.8 | 8.0 | 55.2 | 8.4 | 81.3 | 5.2 | 92.8 | 5.3 | | 1.3 | 49.3 | 11.1 | 12.9 | 12.0 | 34.9 | |
| Chrysler | | 100.0 | 98.7 | | 93.7 | 81.2 | 19.2 | 22.0 | 100.0 | | | | 100.0 | 28.5 | 11.5 | 59.5 | | |
| Newport | | | | | | | | | | | | | | | | | | |
| Total Chrysler Units | 123,159 | 573,412 | 1,031,037 | 173,313 | 722,121 | 23,523 | 758,760 | 81,107 | 221,553 | 747,910 | 273 | 70,303 | 400,213 | 37,022 | 62,810 | 62,810 | 244,613 | 1,241,213 |
| % Total Output | 9.3 | 43.7 | 82.1 | 13.3 | 57.5 | 1.9 | 60.4 | 6.5 | 17.6 | 59.5 | — | 5.6 | 32.6 | 3.0 | 5.1 | 4.2 | 21.5 | — |
| Valiant | 5.2 | 19.3 | 61.0 | 14.1 | 20.0 | | 31.4 | 7.2 | | 53.5 | | 0.3 | 10.7 | 1.9 | 0.9 | | 0.7 | |
| Duster | | 7.2 | 37.2 | 7.1 | 17.4 | | 14.4 | 3.0 | | 31.2 | 1.0 | 0.3 | 11.3 | | | | 0.7 | |
| Demon | | | | | | | | | | | | 0.7 | | | | | | |
| Hornet | 3.7 | 33.6 | 73.0 | 18.1 | 65.8 | | 93.0 | 11.3 | 87.4 | 6.1 | | | 55.1 | 14.0 | 2.2 | 9.6 | 6.2 | |
| Gremlin | 100.0 | 43.7 | 63.1 | 29.0 | 20.8 | | 37.7 | 11.2 | 51.4 | 12.9 | 7.1 | 10.5 | 32.0 | 7.4 | | | 10.1 | |
| Javelin/AMX | 3.0 | | 56.3 | 8.4 | 15.3 | | 11.3 | 2.2 | | 29.5 | | 19.2 | | | | | | |
| Other | | | | | | | | | | | | | | | | | | |
| Total AMC Units | 52,360 | 37,057 | 114,852 | 31,378 | 70,106 | — | 82,303 | 14,700 | 51,307 | 62,604 | 2,051 | 13,042 | 31,772 | 8,243 | 3,705 | 56,353 | 6,600 | 244,713 |
| % Total Output | 21.4 | 15.2 | 47.0 | 12.8 | 28.7 | — | 33.5 | 6.0 | 21.0 | 25.2 | 0.8 | 5.3 | 13.0 | 3.4 | 1.5 | 23.0 | 2.7 | — |
| TOTAL INDUSTRY UNITS | 1,269,753 | 3,004,686 | 5,843,144 | 668,042 | 4,326,347 | 414,604 | 4,133,023 | 390,720 | 1,611,306 | 3,310,008 | 25,946 | 509,046 | 2,499,273 | 813,399 | 321,833 | 167,422 | 553,621 | 7,033,847 |
| % TOTAL OUTPUT | 12.7 | 42.7 | 81.4 | 9.3 | 60.3 | 5.9 | 57.6 | 5.4 | 22.5 | 46.1 | 0.4 | 7.1 | 34.8 | 11.3 | 5.5 | 2.2 | 7.9 | |

Note: All Chrysler Corp. installation rates are based on cars built in U.S. and Canada for sale in U.S. Ford Division rates exclude cars built in U.S. for sale in Canada. Mercury installation rates are based on combined U.S. and Canada output. The Stereo Tape item includes Stereo Radio and Stereo Radio-Tape, but varies by car lines. *Includes 21,656 Ford Club Wagons for which installation rates are not figured.

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[Ct X 6, p 10]

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '72 MODEL CARS

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4-Wheel Disc | Disc Brakes Manual Standard | Disc Brakes Manual Optional | Power Door Locks | Power Seats 2-Way Only | 4- or 6-Way Power Seats | Total Power Windows | Bucket Seats | Rates Stated as % Total Car Output of: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 99.8 | ... | 57.8 | 41.8 | 0.4 | 77.3 | 13.1 | 3.4 | 2.8 | 100.0 | ... | 100.0 | ... | ... | 6.3 | ... | 4.3 | 16.4 | ... | 926,541 |
| Corvette | 100.0 | 46.1 | 76.0 | 21.0 | ... | ... | 72.2 | 26.6 | ... | 88.1 | ... | 69.5 | 30.5 | ... | ... | ... | ... | 95.2 | 100.0 | 38,256 |
| Chevelle | 94.8 | 2.5 | 38.5 | 55.3 | 5.2 | 85.3 | 7.3 | 0.9 | 4.3 | 92.9 | 42.4 | 30.2 | ... | ... | 1.7 | ... | ... | 82.9 | 9.8 | 337,259 |
| Nova | 85.0 | 1.7 | 37.0 | 23.0 | 40.0 | 66.3 | 3.1 | ... | ... | 71.1 | 16.6 | 10.2 | ... | ... | ... | ... | ... | ... | 5.9 | 307,629 |
| Monte Carlo | 99.8 | ... | 51.8 | 43.2 | ... | 69.2 | 21.1 | 6.3 | 14.1 | 100.0 | ... | 100.0 | ... | ... | 1.7 | ... | 2.9 | 9.9 | 9.5 | 107,105 |
| Camaro | 92.7 | 8.5 | 40.3 | 52.7 | 7.0 | 79.1 | 15.2 | ... | ... | 87.2 | ... | 47.6 | 57.4 | ... | ... | ... | ... | ... | 100.0 | 68,805 |
| Vega 2300 | 46.6 | 38.9 | ... | ... | ... | 84.5 | 6.3 | 26.6 | ... | 3.1 | ... | ... | 100.0 | ... | ... | ... | ... | ... | 100.0 | 333,478 |
| Pontiac | 100.0 | ... | 100.0 | ... | ... | 60.1 | 15.6 | 8.6 | 4.8 | 100.0 | ... | 100.0 | ... | ... | 10.1 | 0.2 | 11.8 | 25.4 | ... | 274,021 |
| Grand Prix | 100.0 | ... | 100.0 | ... | ... | 33.5 | 28.8 | 31.0 | 8.4 | 100.0 | ... | 100.0 | ... | ... | 12.9 | ... | 12.9 | 61.5 | 93.2 | 91,955 |
| Ventura | 94.0 | 1.6 | 37.2 | 69.4 | 3.4 | 78.8 | 11.0 | 3.0 | 2.7 | 95.4 | 20.0 | 49.0 | ... | ... | 1.5 | ... | 1.3 | 10.6 | 25.6 | 193,593 |
| Firebird | 87.0 | 9.0 | 57.9 | 34.4 | 3.7 | 71.6 | 15.1 | 8.0 | 7.5 | 96.0 | ... | 65.2 | 34.8 | ... | 2.4 | ... | ... | 7.6 | 100.0 | 89,661 |
| Firebird II | 61.2 | ... | ... | 62.2 | 37.8 | 89.2 | 1.9 | ... | ... | 77.4 | 21.0 | 8.3 | ... | ... | ... | ... | ... | ... | 6.2 | 72,787 |
| Oldsmobile | 100.0 | ... | 100.0 | ... | ... | 53.1 | 10.3 | 26.3 | 7.4 | 100.0 | ... | 100.0 | ... | ... | 25.3 | 1.9 | 25.8 | 42.4 | ... | 274,702 |
| Toronado | 100.0 | ... | 100.0 | ... | ... | 19.6 | 4.9 | 72.1 | 22.9 | 100.0 | ... | 100.0 | ... | ... | 70.0 | ... | 91.5 | 96.7 | ... | 46,153 |
| Cutlass | 92.9 | 0.8 | 100.0 | ... | ... | 75.2 | 11.7 | 6.2 | 3.8 | 94.3 | 42.9 | 43.3 | 0.1 | ... | 2.7 | ... | 2.3 | 17.6 | 22.9 | 221,847 |
| 4-4-2 | 100.0 | ... | 75.4 | 24.6 | ... | 49.4 | 17.0 | 20.3 | 10.2 | 100.0 | ... | 100.0 | ... | ... | 25.3 | 0.3 | 42.8 | 65.0 | ... | 47,197 |
| Delta 88 | 100.0 | ... | 100.0 | ... | ... | 14.0 | 12.7 | 45.3 | 27.0 | 100.0 | ... | 100.0 | ... | ... | 42.4 | ... | 85.4 | 96.0 | 25.7 | 111,743 |
| 98 | 99.2 | 0.3 | 70.3 | 31.7 | ... | 82.5 | 11.9 | 1.2 | 1.6 | 98.3 | 45.6 | 22.5 | ... | ... | 2.1 | ... | 2.5 | 11.5 | 6.3 | 83,743 |
| Ninety-Eight | 100.0 | ... | 100.0 | ... | ... | ... | 25.1 | 24.7 | ... | 100.0 | ... | 100.0 | ... | ... | 50.6 | 3.2 | 95.0 | 100.0 | ... | 41,761 |
| Tot. O'M Units | 4,182,338 | 196,839 | 2,907,143 | 1,111,664 | 208,269 | 3,168,561 | 597,673 | 399,223 | 207,513 | 4,142,155 | 508,213 | 3,156,550 | 448,978 | 0 | 421,659 | 16,969 | 718,621 | 1,442,448 | 558,585 | 4,626,243 |
| % Tot. Output | 90.4 | 4.3 | 62.7 | 24.0 | 4.5 | 68.5 | 12.9 | 13.0 | 4.5 | 89.5 | 11.0 | 68.2 | 9.7 | 0.0 | 13.4 | 0.4 | 15.5 | 31.3 | 12.1 | ... |
| Ford | 100.0 | ... | 67.6 | 32.2 | 0.2 | 77.7 | ... | 13.2 | 2.9 | 100.0 | 0.2 | 92.3 | ... | ... | 7.9 | ... | 6.1 | 22.7 | ... | 771,883 |
| Torino | 97.7 | 0.5 | 36.2 | 73.2 | 3.6 | 85.5 | ... | 7.1 | ... | 95.9 | ... | 62.1 | 37.9 | ... | 0.6 | ... | 1.1 | 15.0 | 5.4 | 481,760 |
| Maverick | 83.5 | ... | ... | 24.6 | 75.4 | 86.5 | ... | ... | ... | 50.7 | ... | ... | ... | ... | ... | ... | ... | ... | 1.3 | 228,760 |
| Montego | 92.4 | 2.7 | 21.9 | 20.4 | 7.7 | 82.1 | 7.4 | ... | 6.1 | 93.2 | ... | 54.9 | ... | ... | 40.8 | ... | 72.4 | 90.9 | 12.9 | 111,015 |
| Pinto | 52.3 | 47.7 | 79.6 | 20.4 | ... | 17.5 | 69.2 | ... | 13.3 | 100.0 | ... | 100.0 | ... | ... | ... | ... | ... | 2.0 | 45.3 | 111,015 |
| Mercury | 100.0 | ... | 75.7 | 24.3 | ... | 82.4 | 1.6 | ... | ... | ... | ... | ... | 87.5 | 0.5 | 40.8 | ... | ... | 90.9 | 12.9 | 84,955 |
| Marquise | 97.2 | 0.2 | 0.4 | 98.8 | 2.8 | 50.7 | 37.7 | ... | 9.6 | 100.0 | ... | 100.0 | ... | ... | ... | ... | ... | ... | 100.0 | 457,355 |
| Cougar | 98.5 | 0.5 | 100.0 | ... | ... | 79.0 | ... | 16.2 | ... | 97.8 | ... | 78.9 | 21.1 | ... | 24.7 | ... | 43.5 | 44.9 | ... | 174,164 |
| Comet | 43.0 | ... | ... | 38.3 | 61.7 | 54.8 | ... | 29.6 | 13.7 | 99.1 | ... | 67.9 | ... | ... | 1.3 | ... | 4.9 | 12.6 | 2.4 | 108,767 |
| Montego | 100.0 | ... | 100.0 | ... | ... | 89.0 | ... | ... | ... | 64.8 | ... | ... | ... | ... | ... | ... | 5.7 | 10.6 | 100.0 | 53,752 |
| Marquis | 100.0 | ... | 100.0 | ... | ... | 9.8 | ... | 74.0 | 16.2 | 100.0 | ... | 100.0 | ... | ... | ... | ... | ... | ... | 1.7 | 49,519 |
| Tot. Ford Units | 2,350,031 | 227,526 | 1,008,606 | 909,160 | 259,617 | 1,978,002 | 115,007 | 250,004 | 73,957 | 1,996,613 | 1,281 | 1,539,395 | 603,690 | 2,543 | 222,106 | 1,609 | 272,459 | 614,148 | 700,827 | 2,633,095 |
| % Tot. Output | 89.3 | 8.5 | 38.2 | 34.5 | 9.9 | 75.1 | 4.4 | 9.5 | 2.8 | 75.8 | 0.1 | 58.5 | 22.9 | 0.1 | 8.4 | 0.1 | 10.3 | 23.3 | 26.6 | ... |
| Fury | 100.0 | ... | 28.0 | 72.0 | ... | 54.9 | 32.6 | 3.5 | 0.5 | 100.0 | ... | 70.7 | ... | ... | 2.4 | ... | 3.3 | 23.2 | 1.5 | 200,252 |
| Satellite | 92.7 | 1.2 | 54.2 | 10.6 | 5.2 | 86.0 | ... | 4.5 | 1.0 | 94.1 | ... | 57.7 | ... | ... | ... | ... | ... | 12.8 | 12.8 | 81,372 |
| Barracuda | 74.9 | 11.7 | 53.4 | 41.5 | 5.1 | 81.3 | ... | 11.8 | 3.6 | 81.7 | ... | 34.4 | ... | ... | ... | ... | ... | ... | 100.0 | 12,403 |
| Valiant | 85.8 | 0.9 | 27.1 | ... | 72.9 | 87.1 | 1.6 | ... | ... | 69.9 | 0.9 | 8.9 | ... | ... | ... | ... | ... | ... | 4.5 | 255,031 |
| Chrysler | 100.0 | ... | 94.3 | 5.7 | ... | 61.7 | 9.8 | 21.5 | 5.2 | 100.0 | ... | 100.0 | ... | ... | 21.5 | ... | 35.5 | 45.7 | 2.0 | 222,754 |
| Imperial | 100.0 | ... | 100.0 | ... | ... | ... | 17.2 | 47.7 | 34.7 | 100.0 | ... | 100.0 | ... | ... | 89.6 | ... | 95.0 | 100.0 | 11.0 | 15,974 |
| Polara | 100.0 | ... | 28.5 | 71.5 | ... | 45.2 | 39.2 | 6.5 | 0.8 | 100.0 | ... | 53.0 | ... | ... | 6.1 | ... | 9.3 | 24.5 | 0.7 | 260,614 |
| Coronet/Charger | 95.2 | 0.6 | 75.4 | 19.5 | 5.1 | 85.1 | ... | 5.8 | 1.3 | 95.4 | ... | 67.3 | ... | ... | ... | ... | ... | 14.2 | 11.0 | 169,783 |
| Challenger | 89.0 | 8.5 | 71.3 | 22.7 | ... | 63.7 | ... | 10.3 | 3.0 | 87.7 | ... | 35.9 | ... | ... | ... | ... | ... | ... | 100.0 | 25,703 |
| Satellite | 93.5 | 0.7 | 35.0 | ... | 65.0 | 92.5 | 1.5 | ... | ... | 66.2 | 0.9 | 10.2 | ... | ... | ... | ... | ... | ... | 2.0 | 127,725 |
| Tot. Chrysler Units | 1,260,612 | 7,621 | 667,939 | 375,007 | 289,813 | 924,914 | 179,118 | 79,435 | 23,083 | 1,216,707 | 3,503 | 709,519 | 0 | 0 | 73,576 | 0 | 113,411 | 223,011 | 181,459 | 1,351,193 |
| % Tot. Output | 94.9 | 0.5 | 50.2 | 28.2 | 21.8 | 69.5 | 13.5 | 6.0 | 1.7 | 91.4 | 0.6 | 53.3 | 0.0 | 0.0 | 5.5 | 0.0 | 8.5 | 21.2 | 7.6 | ... |
| Matador | 97.2 | ... | ... | 75.6 | 24.4 | 63.3 | ... | 1.2 | ... | 87.3 | 24.2 | 21.1 | ... | 0.2 | ... | ... | ... | 9.8 | 1.5 | 54,513 |
| Rebel | 83.3 | ... | ... | 10.3 | 89.7 | 58.6 | 1.8 | ... | ... | 51.6 | 4.7 | 5.1 | ... | 4.7 | ... | ... | ... | ... | 0.6 | 71,055 |
| Ambassador | 100.0 | ... | 59.9 | ... | 0.1 | 73.5 | ... | 7.2 | ... | 99.0 | 60.3 | 29.6 | ... | ... | ... | ... | ... | 23.8 | 0.9 | 66,234 |
| Javelin | 89.9 | 3.7 | 11.9 | 70.5 | 9.6 | 76.3 | ... | 8.0 | 4.9 | 63.2 | 16.5 | 26.6 | ... | 4.4 | ... | ... | ... | ... | 9.3 | 27,176 |
| Gremlin | 55.5 | ... | ... | 10.3 | 89.2 | 58.4 | 1.6 | ... | ... | 21.2 | 1.2 | 1.9 | ... | 4.8 | ... | ... | ... | ... | 4.0 | 61,737 |
| Tot. AMC Units | 214,416 | 1,004 | 47,554 | 78,574 | 132,937 | 166,619 | 2,357 | 6,034 | 1,333 | 166,757 | 40,654 | 41,719 | 0 | 7,409 | 0 | 0 | 0 | 15,011 | 57,527 | 209,425 |
| % Tot. Output | 82.8 | 0.4 | 18.4 | 30.3 | 51.3 | 64.3 | 0.9 | 2.3 | 0.5 | 51.6 | 18.9 | 16.1 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 5.1 | 22.4 | ... |
| TOT. IND. UNITS | 8,011,398 | 427,490 | 4,583,289 | 2,475,405 | 891,636 | 6,223,082 | 894,105 | 934,791 | 305,591 | 7,522,252 | 562,402 | 5,447,543 | 1,052,668 | 9,952 | 917,551 | 18,578 | 1,104,521 | 2,356,225 | 1,413,772 | 8,849,436 |
| % Tot. Output | 90.8 | 4.8 | 51.2 | 28.0 | 10.1 | 70.5 | 10.1 | 10.6 | 3.5 | 85.0 | 6.4 | 61.6 | 11.9 | 0.1 | 10.4 | 0.2 | 12.5 | 26.6 | 16.0 | ... |

Note: Most all Chrysler Corp. and Ford Motor Co. installation rates are based on North American production, but the totals shown for Chrysler in the right hand column are only for U.S. production. General Motors Corp. and American Motors Corp. rates are based only on U.S. production.



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# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '72 MODEL CARS —(Continued)

| | Vinyl Roofs (Non-Convert.) | Sun Roofs | White Sidewall Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Movable Steering Col. | Speed Reg. Device | Reclining Front Seats | Dual Exhausts | Skid Control Device | Parts Based on Total Output of: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 39.8 | ... | 85.5 | 4.1 | 85.4 | 2.5 | 82.1 | 3.7 | 23.1 | 62.4 | ... | ... | 23.1 | 28.5 | 13.8 | 5.7 | ... | 2.8 | ... | |
| Corvette | 3.0 | ... | 66.2 | ... | 100.0 | ... | 63.5 | 100.0 | ... | 13.3 | 100.0 | ... | 100.0 | ... | 42.1 | ... | ... | 100.0 | ... | |
| Chevelle | 44.6 | ... | 87.5 | 1.8 | 79.7 | ... | 62.8 | 6.4 | ... | 49.8 | ... | 50.1 | ... | 11.2 | 5.0 | 1.9 | ... | 3.0 | ... | |
| Nova | 14.8 | ... | 74.1 | 0.2 | 42.9 | ... | 26.2 | 3.3 | ... | 35.4 | ... | 25.1 | ... | 0.7 | ... | ... | ... | 3.5 | ... | |
| Monte Carlo | 44.6 | ... | 95.3 | 1.8 | 78.7 | ... | 91.6 | 6.4 | 100.0 | ... | ... | 47.3 | 100.0 | ... | 19.5 | 1.9 | ... | 6.9 | ... | |
| Camaro | 34.8 | ... | 93.1 | 0.8 | 64.3 | ... | 46.2 | 11.1 | ... | 41.6 | ... | 44.3 | ... | 10.8 | 5.4 | ... | ... | 13.3 | ... | |
| Vega 2300 | | ... | 71.5 | 0.1 | 40.7 | ... | 21.8 | 4.4 | ... | ... | ... | 23.3 | ... | 2.3 | ... | ... | ... | ... | ... | |
| Pontiac | 51.1 | ... | 94.7 | 15.8 | 78.4 | 4.5 | 86.0 | 5.6 | 32.7 | 43.9 | ... | 13.6 | 41.3 | 11.7 | [illegible] | 11.1 | ... | 5.5 | ... | |
| Grand Prix | 89.2 | ... | 94.7 | 7.0 | 90.7 | 5.9 | 90.8 | 7.1 | 21.6 | ... | ... | 78.4 | 100.0 | ... | 25.4 | 1.1 | ... | 11.6 | ... | |
| LeMans | 45.3 | ... | 25.6 | 25.1 | 56.3 | ... | 70.7 | 5.0 | 27.2 | 11.8 | ... | 32.2 | ... | ... | 14.1 | 8.6 | ... | 21.8 | ... | |
| Firebird | 37.0 | ... | 97.0 | 23.5 | 57.8 | ... | 66.6 | 12.6 | 12.6 | 15.0 | 4.3 | 56.5 | ... | 4.3 | ... | ... | ... | ... | ... | |
| Ventura II | 11.8 | 1.2 | 83.2 | ... | 42.0 | ... | 35.1 | 1.3 | ... | 63.9 | ... | 10.9 | ... | ... | ... | ... | ... | 2.2 | ... | |
| Oldsmobile | 60.0 | ... | 96.5 | 10.7 | 85.8 | 8.1 | 84.5 | 5.9 | 84.6 | 14.2 | ... | 1.2 | 32.3 | 26.2 | 35.0 | 16.4 | ... | 10.0 | 2.8 | |
| Toronado | 92.2 | ... | 97.1 | 2.2 | 95.5 | 22.9 | 76.2 | ... | 100.0 | ... | ... | ... | 100.0 | ... | 82.6 | 44.2 | ... | 6.2 | ... | |
| Cutlass | 53.8 | ... | 96.1 | 20.5 | 68.6 | ... | 77.8 | 4.8 | 6.6 | 71.2 | ... | 22.2 | ... | 16.5 | 5.5 | 1.9 | ... | 2.6 | 1.4 | |
| Buick | 65.3 | ... | 96.8 | 11.4 | 85.4 | 7.2 | 85.0 | 7.0 | 70.9 | 21.3 | ... | 43.9 | 32.3 | ... | 42.1 | 28.5 | ... | 2.6 | 5.5 | |
| Riviera | 69.7 | 3.5 | 98.8 | 2.4 | 93.7 | 13.2 | 85.8 | 16.0 | 23.1 | 4.2 | ... | 6.3 | ... | 32.3 | 100.0 | 44.2 | ... | 100.0 | ... | |
| Skylark | 47.2 | 1.7 | 92.0 | 30.9 | 33.5 | ... | 75.2 | 4.2 | ... | 76.9 | ... | 72.7 | 100.0 | 20.0 | 10.5 | 1.5 | ... | 3.8 | ... | |
| Cadillac | 94.8 | 0.7 | 99.5 | ... | 99.6 | 99.6 | ... | 8.5 | 100.0 | ... | ... | 13.4 | ... | ... | 67.6 | 29.8 | ... | ... | 1.0 | |
| Eldorado | 97.2 | 8.0 | 97.7 | ... | 97.6 | 99.8 | ... | ... | 100.0 | ... | ... | ... | 100.0 | ... | 85.7 | 51.9 | ... | ... | 6.0 | |
| Tot. GM Units | 2,164,203 | 10,261 | 4,149,353 | 377,023 | 3,442,254 | 384,229 | 3,063,599 | 269,361 | 1,513,529 | 1,711,500 | 28,292 | 757,069 | 1,252,929 | 846,618 | 2,033,803 | 410,137 | 0 | 226,159 | 14,152 | 4,523,314 |
| % Tot. Output | 45.8 | 0.2 | 87.7 | 8.2 | 74.4 | 8.3 | 66.2 | 5.8 | 32.7 | 37.0 | 0.6 | 16.4 | 27.1 | 18.4 | 43.9 | 8.9 | 0.0 | 4.9 | 0.3 | |
| Ford | 47.9 | 0.1 | 84.3 | 4.9 | 80.2 | 3.6 | 82.0 | 3.3 | 25.6 | 59.0 | ... | ... | 44.0 | 3.1 | 6.6 | 5.3 | 4.8 | ... | ... | |
| Torino | 40.7 | ... | 83.9 | 3.3 | 65.9 | ... | 68.1 | 3.3 | 26.2 | 55.3 | ... | 4.6 | 6.6 | 4.2 | ... | ... | ... | 3.7 | ... | |
| Maverick | 19.5 | ... | 79.9 | ... | 36.5 | ... | 29.5 | ... | 13.7 | 55.8 | ... | ... | ... | 1.4 | ... | ... | 4.7 | ... | ... | |
| Mustang | 32.3 | ... | 79.2 | 5.9 | 55.7 | ... | 43.5 | 4.2 | 36.1 | 44.7 | ... | 6.2 | 14.2 | 21.2 | 3.9 | ... | 7.7 | ... | ... | |
| Thunderbird | 98.3 | 3.4 | 99.9 | ... | 97.7 | 29.6 | 69.3 | 7.1 | 79.3 | 20.7 | ... | ... | 100.0 | ... | 74.5 | 35.6 | 27.1 | ... | 5.8 | |
| Pinto | 5.9 | 1.7 | 74.2 | ... | 34.3 | ... | 18.4 | ... | ... | 79.7 | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | |
| Mercury | 73.5 | 0.2 | 94.5 | 1.5 | 92.0 | 21.9 | 71.6 | 5.9 | 75.4 | 17.0 | ... | ... | 66.0 | 9.6 | 36.0 | 22.9 | 14.9 | ... | 0.9 | |
| Montego | 10.9 | ... | 89.6 | 2.4 | 73.0 | ... | 76.3 | 3.4 | 38.5 | 48.1 | ... | 5.3 | 4.4 | 24.0 | ... | ... | ... | 1.0 | ... | |
| Cougar | 78.9 | 1.0 | 99.0 | 2.1 | 81.4 | ... | 81.2 | 3.5 | 43.0 | 45.0 | ... | ... | ... | 62.4 | 21.9 | ... | ... | 4.9 | ... | |
| Comet | 27.5 | ... | 83.3 | ... | 38.5 | ... | 35.3 | ... | ... | 59.3 | ... | ... | ... | 1.8 | ... | ... | ... | ... | ... | |
| Lincoln | 92.8 | 0.8 | 100.0 | ... | 100.0 | 100.0 | ... | 12.6 | 89.0 | 20.0 | ... | ... | 100.0 | ... | 77.3 | 63.3 | 32.4 | ... | 7.7 | |
| Mark IV | 100.0 | 8.1 | 100.0 | ... | 100.0 | 100.0 | ... | 15.8 | 100.0 | ... | ... | ... | 100.0 | ... | 97.5 | 73.8 | 58.1 | ... | 100.0 | |
| Tot. Ford Units | 1,026,731 | 15,252 | 2,237,972 | 66,595 | 1,662,679 | 176,704 | 1,492,795 | 80,979 | 712,054 | 991,893 | 0 | 30,765 | 655,911 | 156,725 | 349,268 | 171,341 | 127,273 | 29,416 | 56,847 | 2,423,265 |
| % Tot. Output | 43.3 | 0.6 | 83.0 | 2.5 | 63.0 | 6.7 | 56.7 | 3.1 | 27.0 | 37.7 | 0.0 | 1.2 | 24.9 | 6.0 | 9.5 | 6.5 | 4.8 | 1.1 | 2.2 | |
| Fury | 43.9 | 0.1 | 89.0 | 9.8 | 76.5 | ... | 84.6 | 6.2 | ... | 76.7 | ... | 0.8 | ... | 48.9 | 1.3 | 35.3 | 5.0 | 0.5 | ... | |
| Satellite | 48.6 | 0.1 | 63.8 | 13.5 | 57.2 | ... | 65.1 | 6.0 | 14.7 | 56.5 | ... | 10.2 | ... | 35.6 | 0.4 | ... | ... | 4.1 | ... | |
| Barracuda | 51.3 | 0.4 | 82.5 | 18.4 | 37.6 | ... | 33.8 | 22.7 | ... | 32.0 | ... | 53.5 | ... | 8.7 | ... | ... | ... | 41.5 | ... | |
| Valiant | 49.9 | 0.1 | 59.3 | 17.4 | 24.5 | ... | 31.9 | 2.8 | ... | 50.4 | ... | 8.0 | ... | ... | ... | ... | ... | 4.6 | ... | |
| Chrysler | 62.4 | 0.1 | 95.3 | 4.8 | 90.6 | 11.1 | 82.0 | 7.7 | 92.8 | 4.0 | ... | 2.2 | 27.8 | 16.2 | 17.0 | 27.0 | 32.3 | 0.9 | ... | |
| Imperial | 100.0 | 1.4 | 100.0 | ... | 100.0 | 83.8 | 16.2 | 22.9 | 100.0 | ... | ... | ... | 100.0 | ... | 77.5 | 83.3 | 95.2 | ... | 4.0 | |
| Polara | 61.3 | ... | 85.8 | 6.0 | 83.2 | ... | 81.4 | 5.0 | 5.5 | 78.5 | ... | 2.2 | ... | 62.5 | 4.4 | 45.3 | 15.6 | 3.9 | ... | |
| Coronet/Charger | 47.1 | 0.3 | 75.0 | 0.7 | 70.9 | ... | 69.6 | 5.2 | 12.0 | 62.7 | ... | 12.7 | ... | 52.9 | 1.2 | ... | ... | 6.1 | ... | |
| Challenger | 73.4 | 0.6 | 87.9 | 2.5 | 57.6 | ... | 46.8 | 10.7 | ... | 44.8 | ... | 45.3 | ... | 10.6 | ... | ... | ... | 25.7 | ... | |
| Dart | 69.3 | 0.2 | 85.9 | 15.5 | 33.1 | ... | 41.3 | 2.7 | ... | 79.5 | ... | 5.7 | ... | ... | ... | ... | ... | 3.9 | ... | |
| Tot. Chrysler Units | 758,225 | 1,833 | 1,061,158 | 134,427 | 832,543 | 35,983 | 852,530 | 76,108 | 266,406 | 726,441 | 0 | 88,334 | 72,718 | 396,063 | 89,451 | 235,321 | 116,253 | 84,653 | 632 | 1,331,196 |
| % Tot. Output | 43.0 | 0.1 | 79.4 | 10.1 | 62.5 | 2.7 | 64.0 | 5.7 | 20.0 | 54.6 | 0.0 | 6.6 | 5.5 | 29.8 | 44.7 | 17.7 | 8.7 | 6.4 | 0.1 | |
| Matador | 16.0 | ... | 51.6 | 16.7 | 32.0 | ... | 42.5 | 8.9 | ... | 46.0 | ... | 1.1 | ... | 15.9 | 3.0 | 1.1 | 28.6 | 1.9 | ... | |
| Hornet | 5.8 | 0.5 | 47.4 | 7.7 | 36.2 | ... | 37.3 | 3.6 | ... | 41.1 | ... | 7.5 | ... | 12.8 | 3.5 | ... | 32.9 | ... | ... | |
| Ambassador | 23.0 | ... | 69.0 | 16.3 | 69.4 | ... | 92.2 | 14.5 | 59.0 | 14.8 | ... | 1.1 | ... | 40.5 | 16.1 | 9.9 | 58.9 | 9.5 | ... | |
| Javelin | 51.6 | ... | 60.0 | 21.7 | 35.8 | ... | 52.0 | 12.9 | ... | 56.0 | 11.9 | 14.5 | ... | 37.3 | 9.6 | ... | ... | 12.6 | ... | |
| Gremlin | | 1.8 | 27.4 | 8.9 | 22.3 | ... | 26.7 | 3.1 | ... | 15.7 | ... | 40.8 | ... | ... | 1.6 | ... | ... | ... | ... | |
| Tot. AMC Units | 93,851 | 1,425 | 125,756 | 33,802 | 97,731 | 0 | 125,161 | 19,256 | 25,712 | 85,635 | 1,200 | 36,518 | ... | 45,359 | 14,553 | 4,559 | 65,879 | 3,761 | 0 | 239,105 |
| % Tot. Output | 16.9 | 0.6 | 48.5 | 13.0 | 37.7 | 0.0 | 49.3 | 7.4 | 9.9 | 33.1 | 0.5 | 14.1 | 0.0 | 17.7 | 5.7 | 1.9 | 25.4 | 2.4 | 0.0 | |
| TOT. IND. UNITS | 4,093,121 | 29,321 | 7,574,141 | 612,647 | 6,034,657 | 596,896 | 5,534,156 | 445,984 | 2,517,701 | 3,515,719 | 29,512 | 912,609 | 1,981,629 | 1,444,925 | 2,334,457 | 821,737 | 309,425 | 319,719 | 71,231 | 8,849,616 |
| % TOT. OUTPUT | 44.3 | 0.3 | 85.6 | 6.9 | 68.2 | 6.8 | 62.5 | 5.0 | 28.4 | 39.7 | 0.3 | 10.3 | 19.9 | 14.5 | 23.6 | 9.3 | 3.5 | 3.6 | 0.8 | |

Note: Most of Chrysler Corp. and Ford Motor Co. installation rates are based on North American production, but the totals shown for Chrysler in the right hand column are only for U.S. production. General Motors Corp. and American Motors Corp. rates are based only on U.S. production.



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E-1358

ISSUED BY
*Ward's Automotive Reports*
DETROIT, MICH.

OCTOBER 3, 1973

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '73 MODEL CARS

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4 Wheel Disc | Disc Brakes Manual | Power Door Locks | Power Seats 2-Way Only | Power Seats 4-Way Only | Total Power Windows | Bucket Seats | Vinyl Roofs (Non-Convert.) | Optional Axle Ratios Over Those Standard |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 98.5 | | 79.6 | 19.7 | 0.5 | 66.2 | 16.2 | 5.3 | 4.9 | 100.0 | .... | 100.0 | | 10.7 | .... | 5.7 | 20.6 | | 26.6 | 978,053 |
| Corvette | 100.0 | 41.2 | 65.8 | 33.2 | .... | .... | 52.8 | 41.0 | .... | 91.5 | .... | 79.3 | 20.7 | .... | .... | .... | 45.0 | 100.0 | .... | 3,111 |
| Chevelle | 99.9 | 0.5 | 57.1 | 42.9 | 5.0 | 74.7 | 20.1 | 1.5 | 5.1 | 98.4 | .... | 59.6 | 10.4 | 2.1 | .... | 0.6 | 2.0 | 11.0 | 26.6 | 230,742 |
| Nova | 97.6 | 2.2 | 66.6 | 33.6 | 28.8 | 82.5 | 9.2 | .... | .... | 100.0 | .... | 21.0 | .... | .... | .... | .... | .... | 13.0 | .... | 3,000 |
| Monte Carlo | 99.6 | .... | 47.4 | 52.6 | .... | 40.8 | 21.2 | 14.5 | 19.9 | 98.4 | 10.0 | .... | .... | .... | .... | .... | .... | 100.0 | .... | 50,000 |
| Camaro | 97.1 | 11.3 | 38.5 | 61.5 | 3.7 | 60.2 | 20.2 | .... | .... | 100.0 | .... | 100.0 | .... | 11.8 | .... | 4.5 | 22.9 | 20.6 | .... | 247,115 |
| Vega 2300 | 66.4 | 33.6 | .... | .... | .... | 89.8 | 10.0 | .... | .... | 100.0 | .... | 86.4 | 11.6 | .... | .... | .... | 0.2 | 100.0 | .... | 3,000 |
| Monza | 100.0 | .... | 100.0 | .... | .... | 57.4 | 19.1 | .... | .... | 11.0 | .... | .... | 100.0 | .... | .... | .... | .... | 100.0 | .... | 4,000 |
| Corvair | 100.0 | .... | 60.1 | 10.9 | .... | 26.9 | 10.6 | 15.5 | 7.3 | 100.0 | .... | 100.0 | .... | 15.3 | 1.1 | 16.2 | 38.0 | .... | 9.6 | 42,188 |
| Ventura | 98.7 | 1.0 | 33.7 | 66.6 | 1.7 | 66.5 | 16.3 | 49.0 | 26.1 | 100.0 | .... | 100.0 | .... | 27.3 | .... | 25.2 | 69.1 | 91.2 | .... | 97,576 |
| Firebird | 89.2 | 9.1 | 69.5 | 27.5 | 3.0 | 57.0 | 23.0 | 10.2 | 8.1 | 98.3 | .... | 94.6 | 5.4 | 4.0 | .... | 3.5 | 10.0 | 23.0 | .... | 160,592 |
| Phoenix | 98.6 | 1.4 | .... | 72.8 | 27.2 | 86.9 | 4.6 | 15.7 | 14.0 | 99.6 | .... | 88.2 | 11.8 | 4.1 | .... | .... | 11.6 | 100.0 | .... | 246,745 |
| Oldsmobile | 100.0 | .... | 100.0 | .... | .... | 47.8 | 10.8 | .... | .... | 84.9 | 13.0 | 20.1 | .... | .... | .... | .... | 9.2 | 100.0 | .... | 41,213 |
| Cutlass | 100.0 | .... | 100.0 | .... | .... | 14.1 | 4.3 | 35.3 | 10.5 | 100.0 | .... | 100.0 | .... | 34.6 | 1.7 | 30.4 | 46.6 | .... | .... | 49,550 |
| Delmont 88 | 100.0 | .... | 100.0 | .... | .... | 14.1 | 4.3 | 78.6 | 27.9 | 100.0 | .... | 100.0 | .... | 77.8 | .... | 93.1 | 98.9 | .... | .... | 411,332 |
| Ninety-Eight | 100.0 | 0.6 | 100.0 | .... | .... | 64.9 | 12.6 | 17.0 | 10.2 | 99.7 | .... | 97.2 | 2.8 | 5.0 | .... | 5.9 | 9.7 | 31.2 | .... | 55,556 |
| Toronado | 100.0 | .... | .... | 100.0 | 31.9 | 85.6 | 4.8 | .... | .... | 87.4 | 21.3 | 26.5 | .... | .... | .... | .... | .... | 15.3 | .... | 42,553 |
| Buick | 100.0 | .... | 60.3 | 39.7 | .... | 41.3 | 16.1 | 20.9 | 13.1 | 100.0 | .... | 100.0 | .... | 32.6 | 0.2 | 43.9 | 57.5 | .... | .... | 41,153 |
| Skylark | 100.0 | .... | 99.4 | 0.6 | .... | 8.3 | 9.0 | 46.4 | 34.9 | 100.0 | .... | 100.0 | .... | 57.4 | .... | 67.5 | 97.2 | .... | .... | 48,114 |
| Century | 100.0 | 0.1 | 69.1 | 30.9 | .... | 51.8 | 16.5 | 9.9 | 8.1 | 99.4 | .... | 96.1 | 3.9 | 5.6 | .... | 7.2 | 12.5 | 4.6 | .... | 39,505 |
| Apollo | 100.0 | .... | .... | 92.7 | 7.3 | 87.9 | 7.1 | .... | .... | 95.6 | 41.0 | 28.4 | .... | .... | .... | .... | .... | .... | .... | 266,429 |
| Regal | 100.0 | .... | 100.0 | .... | .... | .... | 19.4 | 80.3 | .... | 100.0 | .... | 100.0 | .... | 91.9 | 2.7 | 96.6 | 100.0 | .... | .... | 54,493 |
| Riviera | 100.0 | .... | 100.0 | .... | .... | .... | 6.2 | 93.7 | .... | 100.0 | .... | 100.0 | .... | 95.7 | 1.2 | 93.0 | 100.0 | .... | .... | 59,176 |
| Tot. Cpl. Units | 5,209,337 | 191,194 | 3,412,262 | 1,648,203 | 80,675 | 3,226,973 | 812,712 | 943,432 | 415,691 | 5,060,707 | 75,347 | 4,601,373 | 530,644 | 925,763 | 19,733 | 950,317 | 1,569,990 | 1,184,667 | 2,630 | 5,210,903 |
| % Tot. Output | 94.6 | 3.4 | 61.5 | 27.6 | 1.4 | 57.9 | 14.6 | 16.9 | 7.5 | 93.9 | 1.4 | 82.6 | 9.5 | 16.6 | 0.4 | 17.2 | 28.4 | 20.9 | .... | — |
| Ford | 100.0 | .... | 88.9 | 64.1 | .... | 71.7 | .... | 18.6 | 3.8 | 100.0 | .... | 100.0 | .... | 11.5 | .... | 6.3 | 22.4 | .... | 49.7 | 826,620 |
| Torino | 99.2 | 0.4 | 90.9 | .... | 1.1 | 81.6 | .... | 11.0 | .... | 97.9 | .... | 82.2 | 17.8 | 1.7 | .... | 1.2 | 21.2 | 4.5 | 44.6 | 541,127 |
| Maverick | 89.3 | .... | .... | 39.5 | 60.5 | 55.4 | .... | 4.0 | .... | 74.5 | .... | .... | .... | .... | .... | .... | .... | 1.0 | 5.5 | 51,507 |
| Mustang | 100.4 | 2.9 | 0.6 | 50.6 | 5.8 | 64.9 | .... | 15.5 | 9.2 | 92.9 | .... | 77.9 | .... | .... | .... | .... | 3.0 | 3.9 | 20.9 | 158,032 |
| Thunderbird | 100.0 | .... | 23.7 | 77.3 | .... | 6.2 | .... | 62.9 | 28.9 | 100.0 | .... | 100.0 | .... | .... | .... | .... | 3.0 | 10.0 | 22.5 | 116,591 |
| Pinto | 100.0 | 45.9 | .... | .... | .... | 85.2 | 2.0 | 2.2 | .... | .... | .... | .... | .... | 61.5 | .... | 55.9 | 99.2 | 4.6 | 99.4 | 64,771 |
| Mercury | 100.0 | .... | 62.0 | 38.0 | .... | 42.6 | .... | 4.3 | 14.2 | 100.0 | .... | 100.0 | 89.4 | .... | .... | .... | .... | 100.0 | 9.0 | 45,703 |
| Montego | 99.7 | 0.2 | 1.0 | 99.2 | 0.8 | 69.7 | .... | 28.3 | .... | 99.4 | .... | 77.7 | 22.3 | 31.5 | .... | 50.3 | 72.1 | .... | 72.7 | 184,709 |
| Cougar | 99.3 | 0.7 | 95.3 | 4.7 | .... | 40.5 | .... | 42.0 | 15.6 | 99.1 | .... | 100.0 | .... | 5.7 | .... | 6.3 | 17.6 | 2.0 | 51.8 | 156,155 |
| Comet | 97.1 | .... | .... | 45.9 | 54.1 | 54.2 | .... | 7.9 | .... | 73.9 | .... | .... | .... | .... | .... | 8.4 | 14.7 | 100.0 | 33.3 | 62,939 |
| Montego | 100.0 | .... | 100.0 | .... | .... | 6.4 | .... | 53.2 | 40.4 | 100.0 | .... | 100.0 | .... | 92.7 | 3.5 | 96.5 | 100.0 | 33.3 | .... | 64,525 |
| Monarch | 100.0 | .... | 100.0 | .... | .... | 1.8 | .... | 40.6 | 57.6 | 100.0 | .... | 100.0 | .... | 95.4 | .... | 100.0 | 100.0 | .... | .... | 58,652 |
| Tot. Ford Units | 2,422,317 | 225,199 | 1,074,005 | 1,043,206 | 200,771 | 1,967,040 | 13,553 | 503,159 | 99,533 | 2,220,592 | .... | 1,854,661 | 520,758 | 405,603 | 2,052 | 376,115 | 772,202 | 772,216 | 1,000,111 | 2,703,124 |
| % Tot. Output | 43.5 | 7.9 | 38.5 | 37.6 | 7.5 | 64.4 | 0.5 | 10.1 | 3.6 | 80.0 | .... | 66.5 | 18.7 | 14.6 | 0.1 | 13.5 | 27.8 | 27.7 | 47.9 | — |
| Fury | 100.0 | .... | 88.0 | 77.0 | .... | 71.8 | 10.3 | 5.3 | 0.2 | 100.0 | .... | 100.0 | .... | 5.1 | .... | 3.6 | 24.1 | 1.5 | 42.5 | 260,065 |
| Satellite | 99.4 | 1.2 | 60.6 | 14.2 | 3.8 | 83.2 | 7.3 | 6.0 | 0.2 | 96.5 | .... | 87.1 | 12.9 | .... | .... | .... | 13.3 | 20.5 | 26.6 | 196,791 |
| Barracuda | 80.3 | 9.9 | 9.1 | 35.6 | .... | 77.7 | .... | 16.0 | 3.9 | 82.7 | .... | 76.5 | 21.5 | .... | .... | .... | .... | 100.0 | 5.6 | 19,190 |
| Valiant | 99.4 | 0.6 | 94.9 | .... | 75.1 | 86.2 | 2.5 | .... | .... | 79.9 | .... | 15.0 | 9.8 | .... | .... | .... | .... | .... | 5.5 | 55,725 |
| Dart | 100.0 | .... | 53.2 | 1.8 | .... | 57.2 | 9.7 | 25.0 | 6.3 | 100.0 | .... | 100.0 | .... | 22.9 | .... | 26.7 | 46.0 | 18.1 | 38.6 | 221,529 |
| Demon | 100.0 | .... | 100.0 | .... | .... | .... | 11.0 | 45.1 | 43.6 | 100.0 | .... | 100.0 | .... | 91.1 | .... | 97.5 | 100.0 | 12.1 | 17.6 | 146,539 |
| Challenger | 69.3 | 6.0 | 69.5 | 30.2 | .... | 72.5 | 15.8 | 9.1 | 0.4 | 100.0 | .... | 100.0 | .... | 12.7 | .... | 12.4 | 28.9 | 9.5 | 17.6 | 71,057 |
| Polara | 100.0 | .... | 100.0 | .... | .... | 97.7 | 2.3 | 9.5 | 0.4 | 92.7 | .... | 90.0 | 10.0 | .... | .... | .... | 12.1 | 22.1 | 27.7 | 150,123 |
| Coronet | 99.7 | 0.3 | 96.5 | .... | 55.2 | 93.7 | 4.0 | 15.6 | 0.5 | 93.1 | .... | 76.5 | 23.5 | .... | .... | .... | .... | 100.0 | 7.6 | 100,173 |
| Tot. Chrysler Units | 1,527,017 | 10,035 | 853,502 | 316,712 | 415,504 | 1,206,768 | 123,000 | 119,505 | 21,008 | 1,451,[illegible] | .... | 1,103,[illegible] | 82,573 | 89,219 | .... | 113,[illegible] | 250,200 | 149,[illegible] | 1,[illegible] | 1,044,[illegible] |
| % Tot. Output | 98.3 | 0.7 | 55.0 | 20.3 | 26.7 | 76.1 | 7.8 | 7.5 | 1.4 | 93.4 | .... | 69.4 | 5.4 | 5.6 | .... | 7.2 | 15.5 | 10.5 | 6.7 | — |
| Imperial | 97.8 | .... | .... | 77.5 | 20.5 | 70.6 | .... | 2.8 | .... | 91.6 | 23.9 | 29.1 | .... | .... | .... | .... | 11.1 | 2.9 | 27.1 | 55,772 |
| Newport | 100.0 | .... | 15.0 | 1.9 | 97.0 | 68.5 | .... | 3.0 | .... | 65.1 | 0.5 | 7.5 | 0.1 | .... | .... | .... | .... | 1.9 | 9.8 | 10,154 |
| Newport Custom | 100.0 | .... | 15.0 | 6.2 | .... | 74.5 | .... | 12.4 | .... | 100.0 | .... | 100.0 | .... | .... | .... | .... | 20.6 | 0.7 | 10.3 | 34,174 |
| New Yorker | 97.0 | 3.9 | 2.6 | 94.4 | 7.2 | 69.0 | .... | 14.1 | 8.6 | 98.6 | 15.7 | 97.4 | 5.7 | .... | .... | .... | .... | 0.7 | 10.3 | 39,174 |
| Town & Country | 97.4 | .... | .... | 93.4 | 59.6 | 54.0 | .... | 2.0 | .... | 100.0 | .... | 100.0 | 4.6 | .... | .... | .... | .... | 0.7 | 10.3 | 39,174 |
| Tot. AMC Units | 273,[illegible] | 10,[illegible] | 5,[illegible] | 122,[illegible] | 110,247 | 222,[illegible] | .... | 16,[illegible] | 2,702 | 252,[illegible] | 20,[illegible] | 22,[illegible] | 15,771 | .... | .... | .... | 1,[illegible] | 69,[illegible] | 42,[illegible] | 249,[illegible] |
| % Tot. Output | 5.1 | 0.4 | 0.2 | 4.5 | 4.1 | 8.2 | .... | 0.6 | 0.1 | 9.4 | 0.7 | 8.2 | 0.9 | .... | .... | .... | 0.1 | 2.6 | 1.6 | — |
| TOT. U.S. UNITS | 9,832,[illegible] | 439,[illegible] | 5,340,[illegible] | 3,130,[illegible] | 807,[illegible] | 6,623,[illegible] | 949,[illegible] | 1,582,[illegible] | 538,[illegible] | 5,[illegible],[illegible] | 100,[illegible] | 7,[illegible],[illegible] | 1,[illegible],[illegible] | 1,[illegible],[illegible] | 21,[illegible] | 1,[illegible],[illegible] | 2,[illegible],[illegible] | 2,[illegible],[illegible] | 5,[illegible],[illegible] | 10,[illegible],[illegible] |
| % Tot. Output | 70.4 | 4.1 | 49.1 | 27.4 | 8.6 | 59.9 | 9.5 | 15.1 | 5.3 | 87.7 | 1.0 | 74.5 | 13.2 | 13.8 | 0.2 | 14.1 | 25.7 | 21.4 | 47.9 | — |

Ford: Cougar and Continental Production Ford Versailles on U.S. Built in Canada for U.S. sale. Pinto and Vega engines are 4-cyls. four cylinder. Torino V-8 engine standard in station wagon. Vista Cruiser seats are optional. Chevrolet 4.1; Corvair 15.5; Corvette 33.2; Monza 21.2; Camaro 24.4; Chevelle 6.0; Monte Carlo 10.0; Nova 4.1; Vega 2300 4.0; Monza 2+2 4.3; Monza V-8 30.3; Fury 3.0; Chrysler 30.6; Imperial 98.9; Polara 10.4; Matador 21.4; Monarch 27.0; Ambassador 6.4; Industry Total 3.3

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[Ct X 6, p 13]

R-1359

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '73 MODEL CARS — (Continued)

| | Sun Roofs | Steel-Belted Radial Ply Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited-Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Adjustable Steering Col. | Speed Reg. Device | Dual Exhausts | Skid Control Device | Rear Window Defogger | Remote Control Sub-view Mirror | Opera Lamps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | ... | ... | 4.0 | 88.2 | 3.0 | 84.3 | 4.0 | 25.7 | 58.0 | ... | ... | 20.1 | 14.1 | 19.0 | 8.9 | 12.2 | ... | 15.1 | 88.0 | 9.1 |
| Corvette | ... | 100.0 | ... | 100.0 | ... | 70.8 | 94.1 | 94.3 | 5.7 | ... | 0.0 | 100.0 | ... | 58.9 | ... | 100.0 | ... | 100.0 | ... | 100.0 |
| Chevelle | 0.3 | ... | 2.8 | 72.8 | ... | 66.2 | 4.5 | 15.1 | 55.6 | ... | 9.2 | ... | 15.5 | 9.2 | ... | 11.2 | ... | 11.9 | 4.0 | ... |
| Nova | 0.9 | ... | 1.6 | 47.9 | ... | 34.4 | 4.0 | ... | 44.5 | ... | 23.0 | ... | 7.4 | 2.1 | ... | 4.4 | ... | 3.1 | 20.5 | ... |
| Monte Carlo | 2.7 | 98.3 | 2.9 | 92.8 | ... | 93.7 | 6.2 | 19.7 | 17.3 | 32.5 | 30.5 | 100.0 | ... | 89.5 | 10.9 | 55.6 | ... | 93.8 | 73.6 | ... |
| Camaro | ... | ... | 1.5 | 75.5 | ... | 51.2 | 19.4 | ... | 26.8 | 29.2 | 25.3 | 30.4 | 15.9 | 10.6 | ... | 22.6 | ... | 47.7 | 61.4 | 61.4 |
| Vega 2300 | ... | 2.0 | 0.5 | 43.1 | ... | 25.7 | 4.0 | ... | 60.5 | ... | 29.1 | ... | 30.6 | ... | ... | ... | ... | 15.7 | ... | ... |
| Ventura | ... | 3.6 | 12.3 | 82.6 | 4.8 | 87.3 | 5.2 | 19.2 | 56.0 | ... | 22.2 | 56.7 | 23.9 | 28.2 | 14.4 | 7.2 | ... | 9.9 | 61.9 | ... |
| Grand Prix | 4.0 | 38.4 | 4.9 | 92.6 | 8.1 | 89.1 | 8.2 | 17.0 | 6.5 | ... | 76.5 | 100.0 | ... | 95.4 | 21.0 | 100.0 | ... | 97.0 | 94.7 | ... |
| Caliente | 1.1 | 17.3 | 18.5 | 63.9 | 1.1 | 78.3 | 5.7 | 12.0 | 20.7 | ... | 45.3 | 17.3 | 22.6 | 13.6 | 3.4 | 11.3 | ... | 6.7 | 26.5 | ... |
| Firebird | ... | 6.2 | 14.2 | 61.5 | ... | 66.1 | 20.1 | 11.4 | 11.4 | 10.4 | 59.8 | ... | 13.5 | 15.2 | ... | 20.3 | ... | 15.3 | 60.2 | ... |
| Ventura | ... | ... | 22.1 | 82.3 | ... | 28.7 | 2.3 | ... | 41.8 | ... | 20.4 | ... | 6.2 | 1.3 | ... | 4.4 | ... | 7.2 | 40.0 | ... |
| Oldsmobile | ... | 0.2 | 4.7 | 91.9 | 9.2 | 86.0 | 5.7 | 84.3 | 15.7 | ... | ... | 32.2 | 20.2 | 44.2 | 25.4 | 4.5 | ... | 52.4 | 64.5 | 4.5 |
| Toronado | ... | 1.3 | ... | 98.4 | 26.3 | 73.0 | ... | 80.2 | 19.8 | ... | ... | 100.0 | ... | 89.1 | 60.5 | 100.0 | 3.2 | 60.7 | 100.0 | ... |
| Cutlass | 7.3 | 4.6 | 9.9 | 79.8 | ... | 63.1 | 5.0 | ... | 61.2 | ... | 33.9 | ... | 24.3 | 16.9 | 3.3 | 2.7 | ... | 17.7 | 60.1 | ... |
| Omega | ... | ... | ... | 51.4 | ... | 41.3 | 2.0 | ... | 63.9 | ... | 13.8 | ... | 4.5 | 2.9 | ... | ... | ... | ... | 10.0 | ... |
| Buick | 0.2 | 9.4 | 8.9 | 83.0 | 8.7 | 85.6 | 6.5 | 66.4 | 22.8 | ... | 9.4 | 39.0 | 35.6 | 47.2 | 23.1 | 4.6 | 1.8 | 33.9 | 30.8 | 4.6 |
| Electra | 3.5 | 38.4 | 1.9 | 92.2 | 17.3 | 82.0 | 12.3 | 16.8 | 7.4 | ... | 75.8 | 100.0 | ... | 100.0 | 50.9 | 100.0 | 5.7 | 50.9 | 73.9 | 100.0 |
| Century | 1.1 | 1.9 | 18.6 | 70.3 | ... | 62.0 | 4.9 | 30.7 | 59.4 | ... | 16.5 | ... | 22.3 | 27.2 | 4.4 | 3.1 | ... | 2.1 | 7.6 | ... |
| Apollo | ... | ... | ... | 74.8 | ... | 55.4 | 1.5 | ... | 77.1 | ... | 12.9 | ... | 31.4 | 7.6 | ... | ... | ... | 2.7 | 42.4 | ... |
| Centurion | 1.1 | 25.8 | ... | 99.6 | 99.7 | ... | 7.4 | 100.0 | ... | ... | ... | 100.0 | ... | 25.2 | 27.0 | ... | 1.5 | 50.1 | 57.4 | ... |
| Riviera | 8.9 | 39.7 | ... | 99.7 | 99.8 | ... | ... | 100.0 | ... | ... | ... | 100.0 | ... | 89.3 | 59.7 | ... | ... | 52.0 | 77.5 | ... |
| Tot. GM Units | 63,567 | 669,058 | 305,251 | 4,390,673 | 466,549 | 3,633,012 | 224,691 | 1,537,577 | 2,317,518 | 127,511 | 1,011,717 | 1,672,617 | 995,326 | 1,462,492 | 665,173 | 726,073 | 13,513 | 1,223,[illegible] | 2,941,[illegible] | 5,[illegible] |
| % Tot. Output | 1.2 | 11.0 | 5.5 | 78.0 | 8.4 | 65.9 | 5.3 | 27 | 41.6 | 2.3 | 18.1 | 30.1 | 17.9 | [illegible] | 12.0 | 13.1 | 0.3 | 12.6 | 22.8 | 1 |
| Ford | 0.2 | 19.6 | 4.7 | 80.2 | 4.6 | 84.8 | 3.2 | 21.[illegible] | 60.5 | ... | ... | 65.0 | 0.7 | 9.3 | 7.2 | ... | ... | 14.0 | 78.0 | 80.[illegible] |
| Torino | ... | 0.8 | 4.5 | 70.9 | [illegible] | 76.0 | 2.3 | 22.4 | 57.9 | ... | 5.2 | 3.3 | 0.6 | ... | ... | 2.5 | ... | 5.9 | 74.4 | [illegible] |
| Maverick | ... | 25.8 | ... | 50.7 | ... | 42.3 | ... | 10.2 | 70.5 | ... | 0.9 | ... | ... | ... | ... | ... | ... | 4.8 | 40.5 | [illegible] |
| Mustang | ... | 5.3 | 1.0 | 61.6 | ... | 56.2 | 4.3 | 21.0 | 51.2 | ... | 7.5 | 13.7 | 30.4 | 5.6 | ... | 8.4 | ... | 6.3 | 71.6 | [illegible] |
| Thunderbird | 4.8 | 100.0 | ... | 97.9 | 37.0 | 62.4 | 6.9 | 15.2 | 84.8 | ... | ... | 100.0 | ... | 75.8 | 50.1 | ... | 5.9 | 45.9 | 100.0 | [illegible] |
| Pinto | 2.6 | 13.6 | ... | 42.3 | ... | 25.9 | ... | ... | 71.5 | ... | 4.0 | ... | ... | ... | ... | ... | ... | 4.8 | 29.6 | 41.[illegible] |
| Mercury | 0.3 | 93.0 | 1.3 | 94.1 | 24.5 | 71.2 | 6.5 | 74.9 | 18.3 | ... | ... | 68.3 | 10.2 | 42.3 | 32.7 | ... | 1.4 | 29.4 | 61.[illegible] | [illegible] |
| Montego | 1.1 | 9.3 | 3.2 | 80.2 | ... | 82.4 | 3.1 | 41.9 | 48.8 | ... | 0.4 | 2.8 | 20.8 | ... | ... | 1.9 | ... | ... | 57.0 | [illegible] |
| Cougar | 1.6 | 17.7 | 0.8 | 85.4 | ... | 84.5 | 4.2 | 45.4 | 45.6 | ... | 5.4 | ... | 70.5 | 28.0 | ... | ... | ... | ... | 60.5 | [illegible] |
| Comet | ... | 25.5 | ... | 50.4 | ... | 45.7 | ... | 24.4 | 46.3 | ... | 1.8 | ... | ... | ... | ... | ... | ... | ... | 60.5 | [illegible] |
| Lincoln | 1.4 | 100.0 | ... | 100.0 | 100.0 | ... | 13.1 | 77.1 | 22.9 | ... | ... | 100.0 | ... | 83.1 | 75.9 | ... | 7.0 | 51.4 | 100.0 | [illegible] |
| Mark IV | 10.0 | 100.0 | ... | 100.0 | 100.0 | ... | 13.9 | 100.0 | ... | ... | ... | 100.0 | ... | 92.0 | 80.5 | ... | 100.0 | 57.9 | ... | [illegible] |
| Tot. Ford Units | 26,258 | 724,285 | 67,747 | 1,591,873 | 240,943 | 1,690,943 | 83,671 | 719,705 | 1,599,525 | ... | 64,456 | 900,317 | 215,823 | 352,431 | 262,313 | 14,853 | 170,412 | 342,[illegible] | 1,775,[illegible] | 2,[illegible] |
| % Tot. Output | 0.9 | 26.0 | 2.4 | 71.4 | 8.6 | 60.7 | 3.0 | 25.8 | 57.4 | ... | 2.3 | 32.3 | 7.7 | 12.6 | 9.4 | 0.5 | 6.1 | 12.3 | 63.7 | 1 |
| Fury | 0.1 | 2.2 | 8.9 | 90.8 | ... | 87.0 | 6.6 | 4.5 | 70.9 | ... | 2.0 | 19.3 | 40.0 | 2.9 | 12.4 | ... | ... | 13.3 | [illegible] | [illegible] |
| Satellite | 0.9 | 0.4 | 13.7 | 61.4 | ... | 68.6 | 5.8 | 13.3 | 55.0 | 5.8 | 10.2 | ... | 7.2 | ... | ... | 2.7 | ... | 10.3 | [illegible] | [illegible] |
| Barracuda | ... | ... | ... | 52.5 | ... | 52.5 | 21.4 | ... | 22.4 | ... | 53.1 | ... | 31.6 | ... | ... | 38.6 | ... | 6.0 | 22.9 | 9.[illegible] |
| Valiant | 2.7 | ... | 17.6 | 81.0 | ... | 38.4 | 2.3 | ... | 76.1 | ... | 6.7 | ... | ... | ... | ... | 2.7 | ... | 6.7 | 41.[illegible] | [illegible] |
| Chrysler | 0.2 | 6.2 | 2.7 | 94.4 | 11.5 | 90.3 | 6.7 | 90.2 | 6.2 | ... | 3.6 | 11.5 | 53.4 | 19.5 | 25.7 | ... | ... | 40.2 | 93.4 | [illegible] |
| Imperial | 3.0 | ... | ... | 99.9 | 100.0 | ... | 23.1 | 100.0 | ... | ... | ... | 100.0 | ... | 83.7 | 83.4 | ... | 3.3 | 54.6 | [illegible] | [illegible] |
| Polara | 0.1 | 4.5 | 5.0 | 84.9 | ... | 89.6 | 6.0 | 2.5 | 79.7 | ... | 3.6 | 19.0 | 43.8 | 7.9 | 22.3 | ... | ... | 22.8 | [illegible] | [illegible] |
| Coronet/Charger | 1.7 | 1.0 | ... | 74.3 | ... | 71.7 | 5.3 | 15.7 | 55.4 | ... | 17.9 | ... | 13.8 | ... | ... | 8.6 | ... | 18.9 | [illegible] | [illegible] |
| Challenger | ... | ... | ... | 61.8 | ... | 49.1 | 14.3 | ... | 40.0 | ... | 52.1 | ... | 45.9 | ... | ... | 30.2 | ... | 10.1 | 68.5 | [illegible] |
| Dart | 4.4 | ... | 14.0 | 39.4 | ... | 46.2 | 2.7 | ... | 79.3 | ... | 7.9 | ... | ... | ... | ... | 3.5 | ... | 10.2 | 77.5 | [illegible] |
| Tot. Chrysler Units | 25,542 | 26,239 | 151,871 | 994,272 | 38,545 | 994,269 | 84,185 | 264,283 | 785,195 | 11,237 | 136,422 | 111,688 | 327,783 | 69,208 | 147,676 | 70,513 | 585 | 282,[illegible] | 1,154,[illegible] | 1,[illegible] |
| % Tot. Output | 1.6 | 1.7 | 9.6 | 62.7 | 2.4 | 62.7 | 5.3 | 16.7 | 47.5 | 0.7 | 8.5 | 7.1 | 20.7 | 4.4 | 9.3 | 4.5 | 0.0 | 17.0 | 74.7 | 1 |
| Monaco | ... | 2.2 | 15.3 | 47.0 | ... | 55.7 | 8.3 | ... | 56.7 | ... | 0.9 | ... | 19.7 | 4.5 | 1.5 | 2.7 | ... | 10.8 | [illegible] | [illegible] |
| Hornet | ... | ... | 5.3 | 49.5 | ... | 48.6 | 4.4 | ... | 50.8 | ... | 14.2 | ... | 17.1 | 2.3 | ... | ... | ... | 9.0 | [illegible] | [illegible] |
| Ambassador | ... | 7.4 | 0.1 | 92.7 | ... | 95.2 | 12.8 | 82.9 | ... | ... | 2.6 | ... | 21.5 | 22.1 | 13.0 | 12.6 | ... | 17.4 | 87.[illegible] | [illegible] |
| Javelin | ... | 4.7 | 17.6 | 42.7 | ... | 52.0 | 17.0 | ... | 47.8 | 18.2 | 22.0 | ... | 46.1 | 13.0 | ... | 22.1 | ... | 17.4 | 52.5 | [illegible] |
| Gremlin | ... | ... | 6.0 | 35.0 | ... | 47.5 | 2.7 | ... | 23.9 | ... | 41.4 | ... | ... | 6.6 | ... | ... | ... | 9.9 | [illegible] | [illegible] |
| Tot. AMC Units | ... | 6,256 | 24,203 | 166,027 | ... | 180,162 | 23,052 | 40,696 | 117,663 | 5,707 | 50,345 | ... | 82,[illegible] | 20,[illegible] | 7,[illegible] | 16,[illegible] | ... | 25,244 | 109,[illegible] | 20,[illegible] |
| % Tot. Output | ... | 2.0 | 7.8 | 51.2 | ... | 56.1 | 7.2 | 12.7 | 36.6 | 1.8 | 15.2 | ... | 25.5 | 6.1 | 2.0 | 4.9 | ... | 7.7 | 33.8 | 1 |
| TOT. DOM. UNITS | 115,277 | 1,426,863 | 550,077 | 7,542,147 | 746,040 | 6,659,331 | 515,029 | 2,562,251 | 4,819,931 | 144,505 | 1,269,153 | 2,692,422 | 1,621,683 | 1,934,431 | 1,026,010 | 806,[illegible] | 189,531 | 1,656,[illegible] | 6,001,[illegible] | 10,262,[illegible] |
| % Tot. Output | 1.1 | 13.3 | 5.4 | 73.5 | 7.3 | 65.3 | 5.0 | 25.0 | 47.0 | 1.1 | 17.4 | 29.2 | 15.2 | 18.6 | 10.0 | 8.6 | 1.9 | 16.4 | 59.5 | 1 |

Note: GM, Ford, and Chrysler production figures include units built in Canada for U.S. sale. Pinto and Vega engines are 100% four cylinder. Torino V-8 engine standard includes optional V-8s. Stereo tape includes 8-track, cartridge, Stereo-Pak-o-Tape. Rear Window Defogger includes electrically heated rear window on some models. Percent installation rates for Sentinel Front Seats are as follows: Chevrolet 4.1; Vega 1.5; Ford 10.7; Maverick 25.8; Torino 4.2; Thunderbird 53.2; Mercury 21.3; Comet 24.4; Lincoln 43.0; Mark IV 59.3; Fury 3.0; Chrysler 30.4; Imperial 96.5; Polara 10.4; Monaco 21.4; Hornet 27.5; Ambassador 61.5; Javelin/AMX 58.5; Gremlin 59.9; Hornet SC/360 91.4.

[illegible] [Ct X 6, p 14]

E-1360

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*Ward's Automotive Reports*
DETROIT, MICHIGAN 48226

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '74 MODEL CARS —(Continued)

(MODEL YEAR THROUGH MARCH 31, 1974)

| | Sun Roofs | Steel Belted Radial Ply Tires | Tinted Glass Windshield Only | Tinted Glass Windshield & Other Windows | Air Conditioning Automatic Temp. Control | Air Conditioning Manual Temp. Control | Limited Slip Differential | Wheel Covers Standard | Wheel Covers Optional | Styled Wheels Standard | Styled Wheels Optional | Clocks Standard | Clocks Optional | Adjustable Steering Col. | Speed Reg. Device | Dual Exhausts | Skid Control Device | Rear Window Defogger | Remote Control Saloon Mirror | Cig. Lighter or Total Cigarette |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | .... | 11.2 | 3.2 | 90.7 | 2.9 | 90.9 | 3.5 | 29.3 | 59.2 | .... | .... | 31.9 | 14.6 | 29.0 | 13.3 | 4.9 | .... | 21.2 | 74.5 | 41.7 |
| Corvette | .... | 100.0 | .... | 100.0 | .... | 100.0 | 100.0 | .... | .... | .... | .... | 100.0 | .... | 73.0 | .... | 100.0 | .... | 21.5 | .... | .... |
| Chevelle | 0.3 | 0.2 | 69.4 | 24.1 | 6.5 | 79.5 | 96.9 | 100.0 | .... | .... | .1 | .... | 22.4 | 17.5 | .... | 1.1 | .... | 17.4 | 45.5 | 41.3 |
| Nova | .... | 2.5 | 2.6 | 64.9 | .... | 72.7 | 3.0 | 15.9 | 60.3 | .... | 18.4 | .... | 6.6 | 1.3 | .... | 4.4 | .... | 12.3 | 23.9 | 7.7 |
| Monte Carlo | 2.3 | 100.0 | 3.4 | 94.3 | .... | 33.6 | 2.4 | .... | 71.5 | .... | 28.5 | 100.0 | .... | 45.6 | 14.2 | 4.1 | .... | 23.5 | 69.7 | 37.7 |
| Camaro | .... | 95.5 | 2.1 | 80.7 | .... | 96.1 | 4.0 | 25.8 | 13.6 | 31.3 | 29.3 | 37.1 | 21.5 | 17.1 | .... | 26.0 | .... | 24.4 | 82.4 | 46.4 |
| Vega 2300 | .... | 6.4 | 0.9 | 58.3 | .... | 58.5 | 15.2 | .... | 19.9 | 37.1 | 41.5 | .... | 23.5 | .... | .... | .... | .... | 17.7 | 8.7 | 2.7 |
| Pontiac | .... | 39.7 | 8.2 | 83.3 | 6.3 | 36.0 | 5.2 | .... | 70.9 | .... | 29.1 | .... | 25.2 | .... | .... | .... | .... | 17.0 | 8.3 | 2.3 |
| Monte Carlo | 2.3 | 100.0 | 3.4 | 94.3 | .... | 89.1 | 5.7 | 18.4 | 55.0 | .... | 22.6 | 31.7 | .... | 34.5 | 20.5 | 8.1 | .... | 23.3 | 87.3 | 43.3 |
| LeMans | 1.4 | 25.3 | 17.5 | 71.9 | 1.1 | 96.1 | 7.7 | 8.0 | 5.5 | .... | 86.5 | 100.0 | .... | 63.4 | 28.8 | 100.0 | .... | 15.9 | 77.5 | 37.5 |
| Firebird | .... | 51.3 | 15.2 | 69.5 | .... | 79.6 | 4.7 | 9.1 | 35.9 | .... | 43.1 | 12.6 | 23.8 | 16.4 | 5.5 | 14.2 | .... | 23.0 | 87.1 | 43.3 |
| Ventura | .... | 7.2 | 22.9 | 33.0 | .... | 65.3 | 20.7 | 7.3 | 11.3 | 7.9 | 66.6 | 13.0 | 40.3 | 20.3 | .... | 33.2 | .... | 14.8 | 42.1 | 6.4 |
| Oldsmobile | .... | 20.3 | .... | 97.0 | 59.1 | 32.5 | 3.6 | .... | 43.4 | .... | 23.0 | .... | 8.9 | 2.1 | .... | 11.5 | .... | 4.5 | 23.5 | 1.6 |
| Toronado | 1.2 | 41.9 | .... | 99.3 | 81.1 | 36.4 | 5.9 | 81.2 | 18.8 | .... | .... | 37.9 | 32.7 | 54.6 | 27.6 | 7.1 | .... | 16.1 | 77.1 | 21.4 |
| Cutlass | 4.8 | 22.1 | .... | 92.4 | .... | 18.6 | .... | 100.0 | .... | .... | .... | 100.0 | .... | 90.2 | 75.0 | 100.0 | 2.3 | 26.4 | 77.8 | 37.4 |
| Omega | .... | 4.6 | .... | 43.9 | .... | 83.0 | 3.8 | .... | 57.4 | .... | 36.3 | .... | 25.0 | 22.2 | 5.5 | 6.2 | .... | 11.3 | 37.4 | 6.4 |
| Delta | 0.4 | 24.1 | 5.9 | 91.5 | 13.3 | 34.6 | 1.7 | .... | 62.1 | .... | 18.9 | .... | 5.0 | 3.8 | .... | .... | 2.3 | 23.4 | 93.5 | 17.4 |
| Regency | 4.9 | 65.5 | 1.6 | 97.2 | 26.6 | 81.9 | 7.2 | 60.3 | 23.9 | .... | 13.8 | 41.2 | 28.7 | 54.2 | 38.3 | 13.1 | 6.5 | 57.0 | .... | .... |
| Century | 0.9 | 15.1 | 14.2 | 78.1 | 1.4 | 72.9 | 19.1 | 29.1 | 9.0 | .... | 61.9 | 100.0 | .... | 100.0 | 59.7 | 100.0 | .... | 23.1 | 29.1 | 14.3 |
| Apollo | .... | 5.8 | .... | 71.3 | .... | 84.7 | 4.4 | 13.9 | 51.5 | .... | 30.1 | .... | 33.8 | 36.2 | 6.6 | 4.4 | .... | 16.9 | 45.7 | 4.1 |
| Cadillac | 1.9 | 57.0 | .... | 99.8 | 99.9 | 51.0 | 2.1 | .... | 74.2 | .... | 17.0 | .... | 23.3 | 3.5 | .... | .... | 2.9 | 43.1 | .... | .... |
| Eldorado | 10.9 | 71.3 | .... | 99.8 | 99.9 | .... | 8.1 | 89.1 | 10.9 | .... | .... | 100.0 | .... | 77.9 | 49.4 | .... | 6.2 | 58.6 | .... | .... |
| | | | | | | | | 100.0 | .... | .... | .... | 100.0 | .... | 89.9 | 67.1 | .... | | | | |
| Ford | 0.2 | 69.3 | 3.9 | 85.9 | 5.3 | 85.6 | 3.6 | 18.1 | 68.8 | .... | .... | 65.3 | 4.2 | 12.3 | 12.8 | .... | .... | 16.3 | 79.8 | 41.3 |
| Torino | 0.5 | 50.7 | 7.5 | 73.6 | 1.9 | 81.4 | 3.0 | 29.6 | 54.1 | .... | 2.5 | 33.4 | 6.7 | 5.3 | 4.1 | 2.6 | .... | 12.3 | 45.5 | 8.5 |
| Maverick | .... | 25.9 | .... | 54.4 | .... | 49.3 | .... | 8.7 | 58.4 | .... | 2.4 | .... | .... | .... | .... | 46.1 | .... | 15.2 | 23.9 | 2.2 |
| Mustang II | 4.1 | 62.9 | .... | 42.4 | .... | 39.8 | 2.5 | 60.9 | .... | 29.4 | 9.7 | 23.8 | 7.4 | 81.6 | 63.0 | 32.1 | 7.4 | 33.1 | 71.1 | 29.1 |
| Thunderbird | 10.9 | 100.0 | .... | 100.0 | 55.1 | 44.9 | 8.1 | 37.0 | 63.0 | .... | 3.9 | 100.0 | .... | .... | .... | .... | .... | 88.1 | 98.1 | 58.1 |
| Pinto | 2.2 | 32.4 | .... | 46.3 | .... | 31.7 | .... | .... | 81.2 | .... | .... | .... | .... | .... | .... | .... | 2.6 | 23.1 | 7.1 | 2.1 |
| Mercury | 0.5 | 100.0 | 1.1 | 94.9 | 27.9 | 69.3 | 7.1 | 72.8 | 21.6 | .... | 0.9 | 55.5 | 25.4 | 46.9 | 46.7 | .... | .... | 23.0 | 63.2 | 31.2 |
| Montego | .... | 28.9 | 9.6 | 75.4 | 5.3 | 80.8 | 2.9 | 20.6 | 62.3 | .... | 25.4 | 100.0 | 29.9 | 12.6 | 9.0 | 0.3 | .... | 15.9 | 45.1 | 4.1 |
| Cougar | 3.3 | 99.3 | 2.2 | 90.8 | 13.1 | 80.2 | 5.8 | 38.9 | 35.7 | .... | 3.4 | .... | .... | 32.6 | 18.0 | 3.4 | .... | 8.7 | 45.1 | 4.1 |
| Comet | .... | 28.8 | .... | 57.3 | .... | 52.7 | .... | 22.6 | 46.9 | .... | .... | 100.0 | .... | 85.2 | 82.4 | .... | 8.9 | 65.9 | .... | .... |
| Lincoln | 2.6 | 100.0 | .... | 100.0 | 100.0 | .... | 12.9 | 71.7 | 28.3 | .... | .... | 100.0 | .... | 94.0 | 87.8 | 28.8 | 100.0 | 23.1 | .... | .... |
| Mark IV | 15.2 | 100.0 | .... | 100.0 | 100.0 | .... | 13.1 | 100.0 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| | | | | | | | | | | | | | | | | | | 21.1 | 84.1 | 53.8 |
| Fury | 0.1 | 10.1 | 8.0 | 83.2 | 1.1 | 87.9 | 5.9 | 4.2 | 77.5 | .... | 3.4 | 6.2 | 52.4 | 3.7 | 19.7 | 8.3 | .... | 15.3 | 79.9 | 41.3 |
| Satellite | 97.8 | 0.8 | 88.8 | 8.8 | 3.2 | 78.4 | 4.7 | 10.0 | 57.5 | 4.1 | 10.2 | .... | 6.8 | .... | 6.1 | 14.8 | .... | 12.5 | 47.5 | 22.4 |
| Barracuda | .... | 3.6 | .... | 54.3 | .... | 38.6 | 13.3 | .... | 27.7 | .... | 62.2 | .... | 31.8 | .... | .... | 1.3 | .... | 17.6 | 47.5 | 22.4 |
| Valiant | 1.5 | 7.7 | 17.2 | 34.8 | .... | 43.2 | 1.8 | 2.9 | 73.0 | .... | 4.9 | .... | .... | .... | .... | .... | .... | 5.7 | 9.4 | 4.1 |
| Chrysler | 0.4 | 43.0 | 1.7 | 96.4 | 15.5 | 80.9 | 7.0 | 84.3 | 9.3 | .... | 6.4 | 9.0 | 64.1 | 23.4 | 46.2 | .... | .... | 7.6 | 23.6 | 4.1 |
| Imperial | 6.5 | 100.0 | .... | 100.0 | 100.0 | .... | 21.1 | 100.0 | .... | .... | .... | 100.0 | .... | 84.0 | 89.6 | .... | .... | 33.6 | 93.4 | 53.8 |
| Marcelo | 0.6 | 34.0 | 4.6 | 82.2 | 3.2 | 86.5 | 6.6 | 1.9 | 78.2 | .... | 7.4 | 5.4 | 62.4 | 10.9 | 35.8 | .... | .... | 22.4 | 84.9 | 41.3 |
| Coronet/Charger | 2.2 | 6.8 | .... | 75.6 | .... | 73.0 | 4.4 | 15.3 | 57.7 | .... | 16.3 | .... | 15.2 | .... | 14.0 | 5.3 | .... | 15.9 | 81.7 | 37.5 |
| Challenger | .... | 2.9 | .... | 62.5 | .... | 51.2 | 9.9 | .... | 35.1 | .... | 58.1 | .... | 42.2 | .... | .... | 12.5 | .... | 22.2 | 84.9 | 41.3 |
| Dart | 2.3 | 3.0 | 12.1 | 43.4 | .... | 47.4 | 1.9 | 3.4 | 78.9 | .... | 5.5 | .... | .... | .... | .... | 3.8 | .... | 17.0 | 53.3 | 17.2 |
| | | | | | | | | | | | | | | | | | | 22.1 | 84.1 | 53.8 |
| Matador | .... | 13.4 | 18.8 | 45.2 | .... | 56.9 | 4.7 | .... | 61.0 | .... | 16.3 | .... | 24.6 | 16.3 | 4.5 | 3.7 | .... | 23.5 | 48.7 | 26.8 |
| Hornet | .... | 8.4 | 5.6 | 46.5 | .... | 42.1 | 3.4 | .... | 47.9 | .... | 14.9 | .... | 23.7 | 4.5 | .... | .... | .... | 24.5 | 85.9 | 41.3 |
| Ambassador | 100.0 | .... | 19.8 | 80.2 | .... | .... | 9.5 | 91.4 | .... | .... | 3.9 | .... | 94.3 | 27.2 | 19.1 | 8.4 | .... | 25.1 | 48.7 | 26.8 |
| Javelin | .... | 8.5 | 17.0 | 41.8 | .... | 48.6 | 12.4 | .... | 46.2 | 15.6 | 19.8 | .... | 45.3 | 11.4 | .... | 14.6 | .... | 7.8 | 7.4 | 3.4 |
| Gremlin | .... | 4.9 | 5.4 | 35.9 | .... | 34.8 | 2.2 | .... | 25.0 | .... | 36.4 | .... | .... | 0.9 | .... | .... | .... | .... | .... | .... |

Note: GM, Ford, and Chrysler production figures shown in the far right hand column include units built in Canada for U.S. sale. Rear Window Defogger includes electrically heated rear window or some other device. Remote Control Sideview Mirror includes right-hand remote control mirror installations of 71.1% on Lincoln and 82.0% on Mark IV models.

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ISSUED BY
*Ward's Automotive Reports*
DETROIT, MICHIGAN 48226

MAY 27, 1974

# PERCENT OF FACTORY-INSTALLED EQUIPMENT ON U.S. '74 MODEL CARS

(MODEL YEAR THROUGH MARCH 31, 1974)

| | Automatic Transmission | 4-Speed Synchromesh Transmission | V-8 Engine Standard | V-8 Engine Optional | 6-Cylinder Engine | Radio AM Only | Radio AM/FM Only | Stereo Radio | Stereo Tape Players | Power Steering | Power Brakes 4-Wheel Drum | Power Brakes 2 or 4 Wheel Disc | Disc Brakes Manual | Power Door Locks | Power Seats 2-Way Only | Power Seats 4 or 6-Way | Total Power Windows | Bucket Seats | Vinyl Roofs (Not Convert.) | Cars Built |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chevrolet | 100.0 | | 59.7 | 40.3 | | 64.7 | 17.1 | 6.6 | 5.3 | 100.0 | | 100.0 | | 15.5 | | 2.7 | 16.2 | | 43.5 | 422,991 |
| Corvette | 67.1 | 32.9 | 69.9 | 30.1 | | | 46.5 | 52.2 | | 95.8 | | 88.4 | 11.6 | | | | 68.8 | 100.0 | 1.1 | 21,132 |
| Chevelle | 89.5 | 0.2 | 69.4 | 24.1 | 6.5 | 72.7 | 11.7 | 2.3 | 5.4 | 98.0 | | 92.1 | 7.7 | 3.4 | | 0.9 | 3.4 | 13.8 | 57.7 | 211,673 |
| Nova | 88.8 | 1.2 | 53.7 | 9.5 | 36.2 | 84.8 | 4.4 | 0.3 | | 86.7 | 35.4 | 29.4 | | | | | | 13.8 | 16.6 | 242,421 |
| Monte Carlo | 100.0 | | 51.9 | 43.1 | | 37.4 | 23.1 | 15.7 | 16.7 | 100.0 | | 100.0 | | 13.7 | | 3.6 | 23.4 | 7.5 | 72.9 | 87,511 |
| Camaro | 89.0 | 7.7 | 58.1 | 33.9 | 8.0 | 60.6 | 21.1 | 8.4 | | 100.0 | | 94.2 | 5.8 | | | | | 100.0 | 23.1 | 83,124 |
| Vega 2300 | 57.0 | 36.0 | | | | 78.7 | 12.1 | | | 15.7 | | | 100.0 | | | | | 100.0 | 1.5 | 219,769 |
| Pontiac | 100.0 | | 92.8 | 7.2 | | 52.9 | 19.7 | 20.7 | 11.2 | 100.0 | | 100.0 | | 19.6 | | 19.7 | 42.2 | | 65.1 | 14,765 |
| Grand Prix | 100.0 | | 79.0 | 21.0 | | 24.6 | 14.7 | 53.5 | 33.2 | 100.0 | | 100.0 | | 26.6 | | 29.5 | 75.6 | 91.8 | 80.2 | 71,027 |
| Ventura | 96.7 | 0.5 | 27.3 | 68.1 | 4.6 | 62.2 | 16.8 | 11.6 | 11.1 | 98.5 | | 92.6 | 7.4 | 5.7 | | 4.2 | 11.7 | 37.2 | 55.5 | 10,332 |
| Firebird | 88.5 | 5.7 | 44.5 | 46.7 | 8.8 | 51.6 | 20.4 | 17.6 | 18.1 | 100.0 | | 93.6 | 6.4 | 6.3 | | | 15.5 | 100.0 | 22.5 | 40,595 |
| Venture | 85.1 | 2.4 | | 64.6 | 35.4 | 61.5 | 5.5 | 1.3 | | 86.5 | 14.9 | 23.6 | | | | | | 16.1 | 9.3 | 61,453 |
| Oldsmobile | 100.0 | | 100.0 | | | 40.0 | 10.4 | 43.7 | 13.9 | 100.0 | | 100.0 | | 45.1 | 0.6 | 47.2 | 55.1 | | 71.9 | 165,100 |
| Toronado | 100.0 | | 100.0 | | | 10.9 | 2.7 | 84.9 | 30.8 | 100.0 | | 100.0 | | 88.2 | | 96.3 | 98.1 | | 94.4 | 25,419 |
| Cutlass | 100.0 | | 100.0 | | | 62.5 | 12.4 | 18.9 | 12.4 | 100.0 | | 98.4 | 1.6 | 8.0 | | 5.0 | 13.5 | 36.4 | 62.5 | 473,124 |
| Omega | 92.1 | | | 59.3 | 40.7 | 84.0 | 4.2 | 1.6 | | 89.4 | 22.2 | 32.1 | | | | | | 14.2 | 21.3 | 57,004 |
| Buick | 100.0 | | 64.2 | 35.8 | | 33.2 | 17.5 | 27.8 | 19.5 | 100.0 | | 100.0 | | 43.4 | 0.7 | 50.9 | 64.0 | | 80.9 | 171,238 |
| Riviera | 100.0 | | 90.8 | 9.2 | | 6.5 | 6.9 | 43.6 | 42.0 | 100.0 | | 100.0 | | 70.2 | | 89.5 | 97.7 | | 79.1 | 15,543 |
| Century | 100.0 | | 62.2 | 37.8 | | 56.6 | 18.9 | 10.7 | 10.0 | 100.0 | | 97.3 | 2.7 | 8.6 | | 8.0 | 15.1 | 6.0 | 55.9 | 142,573 |
| Apollo | 95.5 | | | 76.5 | 23.5 | 81.3 | 9.1 | 1.6 | | 92.9 | 33.5 | 35.8 | | | | | | 7.9 | 15.4 | 42,738 |
| Cadillac | 100.0 | | 100.0 | | | | 14.3 | 40.2 | 45.3 | 100.0 | | 100.0 | | 95.2 | 2.3 | 97.7 | 100.0 | | 94.3 | 132,458 |
| Eldorado | 100.0 | | 100.0 | | | | 3.3 | 27.0 | 69.6 | 100.0 | | 100.0 | | 97.6 | 0.6 | 99.4 | 100.0 | | 95.8 | 31,488 |
| Ford | 100.0 | | 100.0 | | | 74.0 | | 15.8 | 3.9 | 100.0 | | 100.0 | | 10.5 | | 10.4 | 31.5 | | 57.1 | 333,127 |
| Torino | 100.0 | | 100.0 | | | 78.2 | | 11.7 | 2.0 | 86.8 | | 92.2 | 7.8 | 3.3 | | 2.0 | 15.3 | | 56.5 | 224,683 |
| Maverick | 90.5 | | | 22.2 | 77.8 | 83.5 | 1.7 | 3.5 | | | | | 30.8 | | | | | 3.6 | 32.5 | 157,515 |
| Mustang II | 69.6 | 30.4 | | | 46.1 | 92.1 | 4.4 | 7.6 | 2.6 | 56.9 | | 40.6 | 59.4 | | | | | 21.9 | 44.4 | 188,319 |
| Thunderbird | 100.0 | | 100.0 | | | 4.7 | | 30.1 | 22.6 | 100.0 | | 100.0 | | 73.6 | | 90.9 | 100.0 | 100.0 | 100.0 | 41,752 |
| Pinto | 58.1 | 41.9 | | | | 78.6 | 3.6 | 3.1 | | | | | 100.0 | | | | | 100.0 | 100.0 | 264,079 |
| Mercury | 100.0 | | 88.8 | 11.2 | | 39.4 | | 39.8 | 17.4 | 100.0 | | 100.0 | | 39.7 | | 52.6 | 75.5 | | 78.7 | 17,729 |
| Montego | 100.0 | | 100.0 | | | 70.5 | | 19.5 | 3.9 | 99.8 | | 84.6 | 15.4 | 6.9 | | 5.5 | 17.6 | | 65.0 | 67,349 |
| Cougar | 100.0 | | 100.0 | | | 35.0 | | 41.2 | 16.8 | 100.0 | | 100.0 | | 13.4 | | 19.2 | 24.2 | 41.2 | 100.0 | 66,515 |
| Comet | 92.7 | | | 24.9 | 75.1 | 80.9 | 2.9 | 7.8 | | 85.2 | | | 31.2 | | | | | 28.0 | 37.2 | 53,153 |
| Lincoln | 100.0 | | 100.0 | | | 4.0 | | 56.1 | 39.9 | 100.0 | | 100.0 | | 95.5 | | 100.0 | 100.0 | | 95.2 | 51,179 |
| Mark IV | 100.0 | | 100.0 | | | | | 40.3 | 59.7 | 100.0 | | 100.0 | | 97.0 | | 100.0 | 100.0 | | 100.0 | 40,529 |
| Fury | 100.0 | | 53.1 | 46.9 | | 71.3 | 14.2 | 8.7 | 2.5 | 100.0 | | 100.0 | | 6.5 | | 6.3 | 22.9 | | 54.0 | 80,891 |
| Satellite | 97.8 | 0.8 | 88.0 | 8.8 | 3.2 | 78.4 | 8.4 | 6.1 | | 94.3 | | 84.7 | 15.3 | | | | 10.2 | 17.8 | 51.6 | 90,177 |
| Barracuda | 84.0 | 4.9 | 85.2 | 14.8 | | 75.1 | | 21.8 | | 92.0 | | 46.5 | 53.5 | | | | | 100.0 | 50.5 | 4,904 |
| Valiant | 87.3 | 0.4 | 25.0 | | 75.0 | 83.3 | 5.9 | | | 83.9 | | 24.7 | 26.3 | | | | | 6.2 | 8.3 | 225,968 |
| Chrysler | 100.0 | | 93.8 | 6.2 | | 45.0 | 15.9 | 33.3 | 10.4 | 100.0 | | 100.0 | | 25.7 | | 44.5 | 54.5 | | 72.7 | 56,323 |
| Imperial | 100.0 | | 100.0 | | | | 7.2 | 92.7 | 52.8 | 100.0 | | 100.0 | | 89.9 | | 97.3 | 100.0 | | 100.0 | 17,035 |
| Monaco | 100.0 | | 45.9 | 54.1 | | 57.6 | 19.4 | 16.5 | 5.4 | 100.0 | | 100.0 | | 18.3 | | 19.7 | 32.8 | | 67.5 | 45,533 |
| Coronet, Charger | 93.8 | 0.4 | 81.1 | 14.5 | 4.4 | 71.2 | 11.7 | 10.9 | | 97.3 | | 87.5 | 12.5 | | | | 17.3 | 21.3 | 73.5 | 84,210 |
| Challenger | 90.5 | 2.7 | 87.5 | 12.5 | | 74.4 | | 22.2 | | 94.3 | | 85.6 | 13.4 | | | | | 100.0 | 79.3 | 12,921 |
| Dart | 94.3 | 0.4 | 31.2 | | 68.8 | 88.1 | 6.2 | | | 87.2 | | 32.5 | 26.7 | | | | | 5.8 | 74.2 | 171,358 |
| Matador | 98.0 | | 7.5 | 67.2 | 25.3 | 74.2 | | 12.0 | 2.1 | 95.3 | | 55.4 | 27.8 | | | | 5.9 | 15.1 | 44.2 | 66,583 |
| Hornet | 87.9 | | | 11.8 | 87.8 | 66.5 | | 7.6 | | 92.2 | 8.8 | 10.1 | 8.9 | | | | | 12.0 | 8.4 | 63,116 |
| Ambassador | 100.0 | | 19.8 | 80.2 | | 74.9 | | 18.6 | 2.0 | 100.0 | | 100.0 | | | | | 32.6 | | 43.8 | 51,054 |
| Javelin | 85.3 | 3.8 | 4.7 | 76.4 | 18.9 | 66.7 | | 16.3 | 8.3 | 93.2 | | 51.2 | 47.9 | | | | | 100.0 | 42.9 | 19,778 |
| Gremlin | 71.3 | | | 9.8 | 90.2 | 64.2 | | 7.1 | | 47.2 | 5.6 | 2.2 | 6.6 | | | | | 46.4 | | 21,260 |

Note: GM, Ford, and Chrysler production figures shown in the far right hand column include units built in Canada for U.S. sale. Pinto and Vega engines are 100% 4-cylinder. Ford Motor Co. V-8 Engine Standard includes optional V-8s on some lines where insufficient data was supplied to give an accurate breakdown. Percent installation rates for Reclining Front Seats are as follows: Chevrolet, 1.3; Ford, 15.0; Maverick, 17.9; Thunderbird, 67.9; Mercury, 26.1; Comet, 22.6; Lincoln, 53.1; Mark IV, 59.2; Fury, 2.7; Chrysler, 46.0; Imperial, 73.1; Monaco, 26.2; Matador, 27.6; Hornet, 31.8; and Ambassador, 72.5. Stereo Tape Players include in some instances Stereo Radio Tape.

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EXHIBIT "B"

| Mfr. | Model Year | 1969 Total Production | 1969 Anti-Skid (Number) | 1969 Anti-Skid (Percent) | 1970 Total Production | 1970 Anti-Skid (Number) | 1970 Anti-Skid (Percent) | 1971 Total Production | 1971 Anti-Skid (Number) | 1971 Anti-Skid (Percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ford | Mark III/IV | 22,564 | 1,692 | 7.5% | 21,432 | 21,432 | 100.0% | 27,091 | 27,091 | 100.0% |
| | Thunderbird | 49,272 | 148 | 0.3 | 50,364 | 1,108 | 2.2 | 36,055 | 2,632 | 7.3 |
| | Lincoln | (Anti-Skid Not Offered) | | | 37,695 | 3,732 | 9.9 | 35,551 | 3,021 | 8.5 |
| | Mercury | ( " | " | " ) | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | Other Ford | ( " | " | " ) | ( " | " | " ) | ( " | " | " ) |
| | Total Ford | 2,144,928 | 1,840 | 0.1% | 2,036,211 | 26,272 | 1.3% | 2,141,837 | 32,744 | 1.5% |
| GM | Toronado | (Anti-Skid Not Offered) | | | 25,475 | 459 | 1.8% | 29,265 | 1,931 | 6.6% |
| | Cadillac | ( " | " | " ) | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | El Dorado | ( " | " | " ) | 23,842 | 143 | 0.6 | 27,368 | 1,177 | 4.3 |
| | Other GM | ( " | " | " ) | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | |
| | Total GM | 4,415,511 | 0 | 0% | 4,095,419 | 602 | 0.01% | 3,556 263 | 3,108 | 0.1% |
| Chrysler | Imperial | (Anti-Skid Not Offered) | | | (Anti-Skid Not Offered) | | | 11,432 | 263 | 2.4% |
| | Other Chrysler | ( " | " | " ) | ( " | " | " ) | (Anti-Skid Not Offered) | | |
| | Total Chrysler | 1,479,459 | 0 | 0.02% | 1,311,073 | 0 | 0% | 1,256,259 | 263 | 0.02% |

B

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STATE OF NEW YORK
COUNTY OF } ss.:

The undersigned, an attorney admitted to practice in the courts of New York State, certifies that the within has been compared by the undersigned with the original and found to be a true and complete copy.

Dated:

VERIFICATION, CORPORATE OR INDIVIDUAL

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes:

Deponent is the of a corporation in the within action;

Deponent has read the foregoing and knows the contents thereof; the same is true to deponent's own knowledge, except as to the matters therein alleged upon information and belief, and those matters deponent believes to be true.

The grounds of deponent's belief as to all matters not stated upon deponent's own knowledge are as follows:

Sworn to before me,
this day of 19

AFFIDAVIT OF PERSONAL SERVICE

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes and says, that deponent is not a party to the action, is over 18 years of age and resides at
That on the day of 19
at No.
deponent served the within
upon
the herein,
by delivering a true copy thereof to h personally.
Deponent knew the person so served to be the person mentioned and described in said papers as the therein.

Sworn to before me,
this day of 19

AFFIDAVIT OF SERVICE BY MAIL

STATE OF NEW YORK
COUNTY OF } ss.:

being duly sworn, deposes and says; that deponent is not a party to the action, is over 18 years of age and resides at
That on the day of 19
deponent served the within
upon
attorney(s) for
in this action, at
the address designated by said attorney(s) for that purpose by depositing a true copy of same enclosed in a postpaid properly addressed wrapper, in — a post office — official depository under the exclusive care and custody of the United States post office department within New York State.

Sworn to before me,
this day of 19





ATTORNEY'S AFFIRMATION

STATE OF NEW YORK
COUNTY OF } ss.:

The undersigned, an attorney admitted to practice in the courts of New York State, hereby affirms as true under all the penalties of perjury that affiant is

the attorney(s) of record for in the within action; that affiant has read the foregoing and knows the contents thereof; that the same is true to affiant's own knowledge, except as to the matters therein stated to be alleged on information and belief, and that those matters affiant believes to be true. Affiant further says that the reason this verification is made by deponent and not by

The grounds of affiant's belief as to all matters not stated upon affiant's knowledge are as follows:

Dated 19

Index No. 66 CIV. 665 Year 19(KTD)
UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

PERMA RESEARCH & DEVELOPMENT COMPANY,
Plaintiff,
- against -
THE SINGER COMPANY,
Defendant.

STIPULATION OF FACTS

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for Plaintiff
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N. Y. 10017
(212) 888-3200

To

Attorney(s) for

Service of a copy of the within is hereby admitted.
Dated, 19

NOTICE OF ENTRY

Sir: Please take notice that the within is a
duly entered in the office of the clerk of the within
named Court on 19

Yours, etc.

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N. Y. 10017

NOTICE OF SETTLEMENT

Sir: Please take notice that an order
of which the within is a
will be presented for settlement to the
Hon. one of the judges of the within named Court, at
on the day of 19
at M.

Yours, etc.

POLETTI FREIDIN PRASHKER FELDMAN & GARTNER
Attorneys for
Office and Post Office Address
777 THIRD AVENUE
NEW YORK, N.Y. 10017